FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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Cover—Construction slash along road corridors between cutover areas is fuel for wildfire. Besides being an eyesore, it can create problems in future timber harvesting. See story next page.

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Road Construction Slash . . . Potential Fuse for Wildfire?

JOHN D. BELL [1]

Slash from road construction is likely to serve as a connecting link between patches of highly flammable fuels, such as clearcut units. Increased "fire rate of spread" and increased difficulty in using roads to move men and equipment often result.

Construction debris along permanent and spur logging roads can be a fire hazard if slash is not adequately disposed of during road clearing. Roadside slash includes cull logs, branchwood, snags, brush, and other vegetation (cover). Besides its high fire hazard potential, roadside debris is esthetically unattractive. And where right-of-way material is piled against standing timber, it can create problems for future harvesting.

In the Douglas-fir region, construction slash on interlinking roads between freshly logged patch cuttings has served as a connecting fuse for the spread of wildfire.

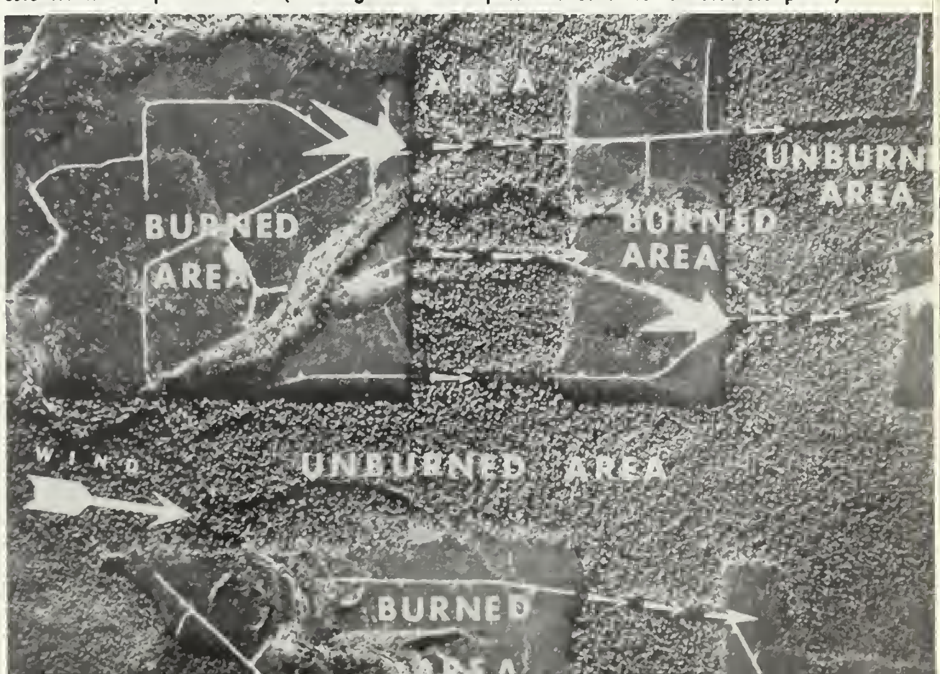
Raft River Fire, 1967

An example of a fire spread by right-of-way slash is the Raft River Fire of July 1967. This fire started on private land within the Quinault Indian Reservation in northwest Washington after several weeks of dry, warm weather and fire danger buildup. The fire started on a clearcut logging operation in heavy slash and spread over 4,500 acres during a 4 day period. Northwesterly winds fanned the flames through the heavy slash in the cutover areas, but spread was usually checked by the adjacent green timber. More than 85 percent of the area burned was untreated cedar and hemlock logging slash. The remaining burned acreage was reproduction and old-growth timber — mostly fringe areas around clearcut boundaries and along the edge of connecting roads between units. In a number of instances, firefighters reported that the fire funneled from clearcuts into road corridors and then spread rapidly through construction slash into adjacent clearcut units (fig. 1). They also observed spot fire ignitions in the roadside slash with subsequent rapid linear spread. The intense heat and smoke from fires along these connecting roads hampered movement of men and equipment to control the fire.

Action Planned

Construction slash should be of concern to agencies responsible for forest protection. In Oregon and Washington, the Forest Service is now in the process of revising its regional slash disposal policy to improve and update fuel treatment methods. Included in the policy now being formulated are requirements for complete disposal of all road construction slash in Land Management Units (LMU) and on Land Access Roads (LAR) in the National Forests. Roadside slash cleanup will contribute to safer, more effective fire control where forest roads are used directly as control lines. In addition, the possibility of fire spread through roadside slash corridors will be reduced. △

Figure 1—Portion of the 4,500-acre Raft River Fire. The two large arrows show where the hot slash fire funneled into the road corridor, spread along the construction debris, and swept into adjoining cutovers, where topography was nearly level. The distance between cutovers is one-quarter mile. (Washington State Department of Natural Resources photo)



[1] Forester, Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif., stationed at Portland, Ore.

Automated Forest Fire Dispatching ... A Progress Report[1]

Ernest T. Tolin, James B. Davis, and Conrad Mandt[2]

Computers may offer a way of speeding up forest fire dispatching. Results of tests made on a prototype system suggest that automated fire dispatching is feasible and can be a useful tool to both the skilled and unskilled dispatcher.

Time was when forest fire control "dispatching" meant impressing into service any unfortunate soul who happened to be near the fire. Today, impressing is no longer done. Instead, most dispatchers control large, complex organizations already set up that include men, vehicles, and aircraft. The dispatcher has the problem of keeping track of these resources, and he must move them quickly and efficiently to a fire.

Computer technology may offer a solution to this problem. A switch to automatic data processing is not justified, however, merely because it is modern technology. The computer must prove itself "cost effective"; it must make dispatching cheaper, faster, or more accurate.

Any system, if it is to be the most helpful to the dispatcher, must:

- Give more information than even a skilled dispatcher might normally possess and give it quickly.
- Yield a permanent written record at least as good as the log now kept by hand.
- Keep an up-to-the-minute record of location and strength of all firefighting resources.
- Help in planning crew locations, road system modifications, and other potential changes.
- Be useful as a training aid for new personnel.

From a practical viewpoint, a system should be designed so that it meets all of these requirements with existing personnel and a budget that a forest fire control organization can afford.

WHAT RESEARCH IS DOING

The idea is to have a command and control system for a dispatch office that can weigh the cost of fire suppression against values protected. The system would be able to consider variables of topography, weather, fuels, and resource values and then recommend the dispatch of those fire fighting resources best able to control the fire. (1–4)

This paper reports the first of a series of steps aimed at reaching this goal. A prototype system was developed and was tested during the 1968 fire season. Our objectives were to (a) define dispatcher needs and specify requirements for an operating system; (b) determine the feasibility of computer dispatching; (c) develop a prototype computer dispatch system that will use network or graph theory; and (d) test the feasibility of a remote computer terminal operating from a central time-sharing computer.

Specific Requirements of the System

Besides providing estimated time of arrival at a fire and recommended travel routes, an automated dispatch system must be able to store and retrieve information on firefighting resources by providing for:

- Up-to-the-minute display of available firefighting resources.
- Easy update of the inventory when resources are transferred from one site to another.
- Ability to account for resources transferred in or out of the dispatcher's area of control. (This quality would be particularly important for keeping track of large quantities of resources used in combating a major fire.)
- Inventory of resources that have been assigned to a fire. (The skilled dispatcher may know local resources and their travel routes and times to any fire within his area, but few dispatchers can keep track of the identity and disposition of outside forces brought in during emergencies.).
- Printout, on demand, of forces assigned by cooperating organizations.

In the summer of 1968, the Pacific Southwest Forest and Range Experiment Station joined forces with the California Division of Forestry in developing and testing a prototype system. The test was held in an area assigned to the San Bernardino County Ranger Unit.

[1] This article first appeared in FIRE TECHNOLOGY, May 1969.

[2] Respectively, computer-programmer and project leader, Forest Fire Laboratory, USDA Forest Service, Riverside, Calif.; and highway engineer, Transportation System Planning Study, Division of Engineering, Region 5, USDA Forest Service, San Francisco, Calif.

From the results, we concluded that automated dispatching is feasible and can be a useful tool. Its importance to a fire control organization, at least in the initial stages, is probably inversely proportional to the skill of the dispatcher; that is, an unskilled dispatcher probably needs the system more than a skilled one. The system becomes more useful as fire complexity or load increases, and it should be helpful where there are mutual-aid arrangements or overlapping jurisdictions. But we have a long way to go in speeding up the system's response time and in making it "fail safe." We found that the computer was used much more than we had ever anticipated. Dispatch and subsequent follow-up dispatch action form a complicated process involving continual dialogue with the computer during the life of the fire. Consequently, the computer becomes a colleague rather than a tool for the dispatcher.

Test Area

The organization selected for the test—the San Bernardino Ranger Unit—protects an area that has many fires and some of the world's most valuable watershed land. The Unit controls a large number of firefighting resources and has developed strong mutual-aid agreements. The interest and progressive attitude of the ranger and his dispatch staff were important factors in our decision to test the system here. The California Division of Forestry spent several weeks in measuring travel times and inventorying the equipment to be used in the system.

Computer Hardware

Initial versions of the computer program were developed on IBM 7040 and CDC 6400 computers. Both machines were owned by the University of California.

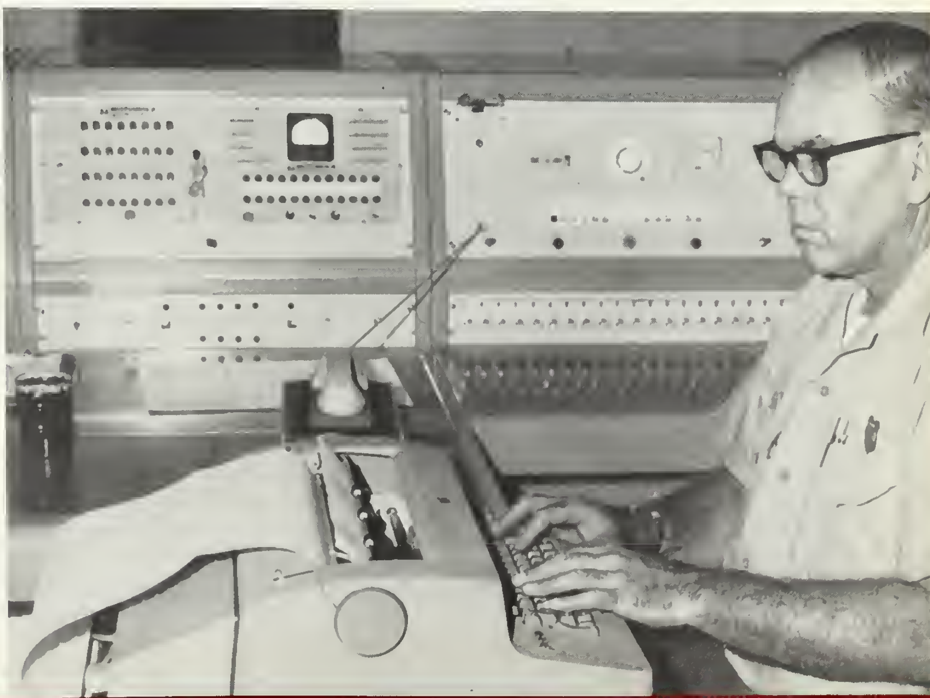
We decided to use a commercial time-sharing service for the prototype system. These services use terminals, little more complicated than electric typewriters, that are connected by regular telephone lines to a computer center. Since a single large computer can service many such terminals, its cost can be shared, making the service available to a large number of users who could not otherwise afford computing equipment. Once the programming job has been done, time-sharing allows the use of normal language. The user can talk freely with the computer in ordinary English by typing on the keyboard. The typewriter is fast enough for most uses—as fast as 15 characters per second. At this rate, information can be transmitted by conventional commercial telephone lines. (5) All the dispatcher sees, then, is a typewriter on his desk tied into his telephone system. However, he is connected directly to a computer—in our case 70 miles away—capable of making mathematical computations in billionths of a second (fig. 1).

Our next step was to analyze commercially available time-sharing systems. (6) Many factors had to be considered, including computer core size, access to storage, load and compile time, reliability of the system, and the time that the system would be available. We contracted with the Allen-Babcock Computing, Inc.

HOW THE SYSTEM WORKS

How does our computer program work? The crux of the problem is to get men and equipment from one place to another as quickly as possible. The computational procedure used by the computer is based on network or graph theory. (7) When we talk about graphs,

Figure 1—Operatar gives instructions ta a time-sharing camputer, lacated 70 miles away, by typing on an electric typewriter. Telephone lines connect this terminal to the computer.



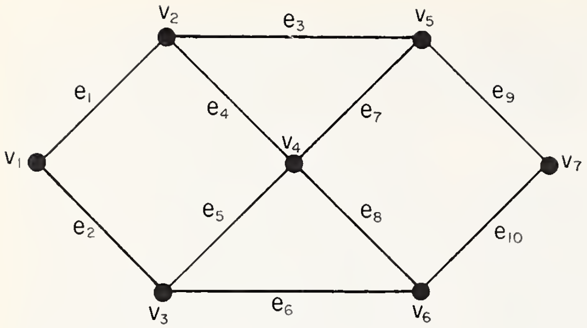


Figure 2—Simple network or graph shows 7 nodes connected by 10 links.

most of us picture a chart showing the interrelation between a set of variables. The kinds of graphs we are using, however, are geometric structures consisting of points (nodes) connected by a system of lines (links). (8-10) The interrelation of these nodes and links forms a network that can be an abstract concept or a model of a real situation, such as a pipeline complex, an electrical system, or—as in our case—a network of roads (fig. 2).

Mathematical Theory

Pairs of nodes are connected by links to form a network. A path can be formed from a point to any other point in the network. Each link has a travel time from one end to the other that may be different in each direction and in each time interval. For forest roads or trails, each junction would constitute a node.

If no cycles, or distinct paths, lead from a node back to the same node, the network is called a tree. A tree that reaches all of the nodes of a graph is called a spanning tree (fig. 3). The simplest tree graph is a line connecting two nodes but the number of possible trees increases rapidly as the graph increases in size. For example, four nodes can be connected in 16 possible ways. Consequently, there may be hundreds, perhaps thousands, of different spanning trees within our 158-node forest road system. There is ususlly one best spanning tree. (11) The computer must pick, out of all the thousands of combinations, the one best spanning tree (12, 13) This best or "minimum spanning tree" will show the route that fire equipment should use when going to any fire within the forest area covered by the network.

For practical purposes then, the forest fire or administrative road system can be compared to a graph. The intersections and other points of interest may be considered nodes. Each node is assigned a code number. The interconnecting roads are the links. Some nodes represent actual fire control stations; others represent key areas near which fire suppression crews may be operating. But we do not have to limit ourselves to regular agency crews. We can consider any firefighting force, such as logging crews, public utility crews, and equipment of cooperating agencies.

A necessary feature of the system is that crews can be readily reassigned throughout the area. Each crew is assigned a code number. To reassign crews the dispatcher follows a

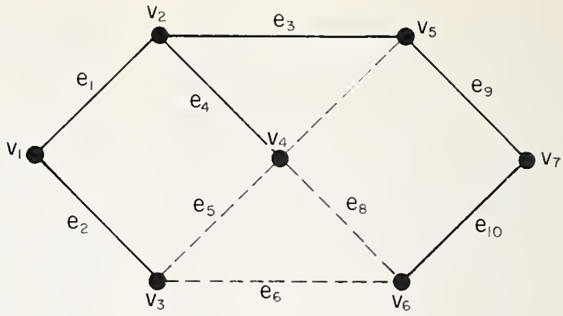


Figure 3—Lines indicate a spanning tree or a minimal connected graph.

simple updating routine on his typewriter. For the most part, crews will represent fire control forces within the dispatcher's normal span of control. Empty or unassigned nodes within the network are not recorded within the computer's equipment register. (14) The location of a node in the network shows the computer where to look in its disk file for an accurate description of the equipment at a particular location.

Computer Response

Within the computer's memory, each word of information is given a number by which it is identified. This number is called its address. Access to a particular word of memory is achieved by specifying an address as a binary coded number. The prototype system uses a random access disk. Access time to the disk does not depend on the sequence in which the words are entered or extracted. By using the equipment-filing system housed within the computer memory, we can rapidly update information on the disk. When a crew is dispatched from its present location to the fire or to another location, the dispatcher updates the computer record by typing in the crew's code number and the code number of

the new location. The actual dispatch goes through these steps:

- The computer calculates the minimum travel times from all nodes to the fire using the spanning tree algorithm. Instead of printing out this information, however, the computer retains it in temporary storage.
- The computer then examines travel times, finds the shortest time, and searches the equipment register for possible resources. When it locates a piece of fire equipment that is closest to the fire, it automatically gives a recommended dispatch for that piece of equipment. The computer repeats the sequence until either all resources are located or the dispatcher stops the procedure.
- Finally, resources, their locations, travel routes, and travel time to the fire are printed out (fig. 4). The format can be modified as experience in dispatcher requirement is gained.

WHAT WE LEARNED

The system began operating on August 13, 1968. For an average 15- or 20-acre fire, the dispatcher used his terminal for about 100 minutes. The computer center was called 1,325 times during the 1-month period in which 60 fires occurred (not all of these calls were for fire control—program modification and demonstrations to "visiting firemen" were also involved. Lapsed time from a call until the computer answered averaged 1 minute 23 seconds. Ideally, the dispatcher would like to have his answers in about 4 to 5 seconds.

The relatively long time required by the prototype system included several seconds needed to dial the computer center and time required to log into the center and call up the dispatch program from the system's disk file. The dispatcher took additional seconds to type in fire location and other procedural instructions. Finally, the computer had to calculate the quickest route from the crew locations to the fire.

Consequently, when a dispatcher received a fire call, he sent some of his initial-attack forces and, about the same time, dialed the computer. By the time the first two or three crews were underway, he was beginning to get a response from the computer. He would then ask the computer for follow-up dispatch information. He would begin to update his equipment inventories, perhaps make a second follow-up dispatch if conditions warranted it and, again, update. Then he might call for a status check on the location of all equipment. Perhaps equipment from outlying stations was moved to those vacated for the fire. Equipment was often released in several steps. Some equipment would be returned directly to its home station, while other items might be transferred elsewhere or even sent to a second fire.

This movement resulted in far more use of the computer than we had anticipated. The system holds promise of being a much more useful, and consequently more valuable, tool than we had expected. On the other hand, it made our test program more expensive than we had anticipated.

At prevailing rates, it costs about $100 to make a dispatch to a 15-20-acre fire. But $100 could also buy about 5 hours of D-8 bulldozer time or a couple of hours of 25-man crew time.

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```
\XEQ GO
DO YOU HAVE A FIRE ??
\YES
WHERE IS THE FIRE
NHOME
\75
ENTER 0 TO SUPPRESS ROUTES ELSE ENTER 1
ENTER NO OF RESPONSES YOU WANT FROM TO
NCOLST
\1,1,3
690107    1030
RESPONSE NO. 1. IS FROM NODE 2.  ETA IS 3.  MIN.
TRAVEL IS FROM NODE 2.  TO NODE 78.
               NODE 78.  TO NODE 75.

EQUIPMENT AT THIS STATION IS:
          571   CDF FTH 500 GAL

690107    1030
RESPONSE NO. 2. IS FROM NODE 18.  ETA IS 8.  MIN.
TRAVEL IS FROM NODE 18.  TO NODE 57.
               NODE 57.  TO NODE 58.
               NODE 58.  TO NODE 59.
               NODE 59.  TO NODE 75.

EQUIPMENT AT THIS STATION IS:
          283   CDF FTH 500 GAL

690107    1031
RESPONSE NO. 3. IS FROM NODE 5.  ETA IS 9.  MIN.
TRAVEL IS FROM NODE 5.  TO NODE 85.
               NODE 85.  TO NODE 75.

EQUIPMENT AT THIS STATION IS:
          589   CDF FTH 500 GAL

          060   CDO FTH 500 GAL
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Figure 4—Dispatch order and reassignment of fire fighting forces may be printed out by the typewriter terminal in this form.

Thinning Slash and Fire Control

Robert W. Appleby [1]

The effect on fire control of thinning timber stands cannot be generalized. The results must be considered as applying only to the topography of a given site and only under the stand conditions and fuel factors that exist on that site.

[Editor's note: Robert W. Appleby's article is in response to an invitation to comment on an article by Robert Cron in the Winter 1969 issue of *Fire Control Notes* (Vol. 30, No. 1). The subject of Cron's article was thinning and its effects on fire control (Thinning As An Aid to Fire Control, p. 3).]

As Robert Cron's article in *Fire Control Notes* points out, there have been many debates regarding the relationship of thinning slash to fire control. I do not believe Cron's article really deals with the thinning slash problem in itself, but simply compares observations of fire actions in a pole and sapling stand and a stand that was thinned. Most people would agree that it is easier to build a dozer line through a 2- or 3-year old thinned stand than through a green, uncut stand—all other things being equal. This is simply a matter of mechanics.

In many situations, I am sure that expert fire control men would rather burn out from a line in thinning slash than they would in some pole and sapling stands. Here again, each situation is different.

Determination of fire behavior in any particular situation is not unlike determining a stumpage price through the appraisal system. There must be a complete analysis of the data affecting all the factors of the operation before the proper decision can be made.

[1] Branch Chief, Prevention and Hazard Reduction, USDA Forest Service, R-6, Fire Control.

Figure 1—Ponderosa Pine Thinning Slash.

What We Need to Know

Following are some of the facts we need to know in making a true comparison of fire control in thinned and unthinned stands:

1. What was the weather situation at the time of each burn situation?

2. What diurnal weather changes were involved? The burning index drops off sharply after the middle of the day, and thirty minutes could make a considerable difference in burning conditions. Because the thinned area burns, as pointed out in Cron's article, were evidently later than the unthinned stands, this could have been a factor. (1)

3. What was the topography in front of and behind each fire situation?

4. What were the fuel conditions in each area burned?

5. What temperature, wind, and humidity occurred during the two situations?

6. What tonnage of fuel was on the ground below the pole and the sapling stand?

7. What was the age, species composition, average diameter, number of stems per acre, and ground cover in each situation? Rate of spread and resistance to control depends on these elements. (2)

8. What was the moisture content of each fuel situation? In a season such as 1967, the moisture content in evergreen foliage is considerably reduced. (3), (4)

9. What was the temperature of the fuel under each burning situation? Cron points out in one instance that green brush (mostly alder) was growing heavily as an understory beneath the thinned larch. This could change the

thinning slash combustion characteristics if the facts here were known.

10. What where the fuel type ratings in each situation? Fire control action is principally based on two elements, namely, rate of speed and resistance to control.

The combination of factors that determines the rate of spread of a fire and the resistance to control are complex, variable, and interrelated. Most observations, whether they favor thinned or unthinned stands, are observations relating to large fire control.

Controlling a large project fire and controlling a small fire have entirely different management considerations. (4) While thinning slash may not be a serious problem in building a fireline a mile away from the fire front with d-9 dozer, it will have a serious effect on the ability of two men with axes and shovels to construct a line. The rate of spread factor of fuel is more a matter of logistics in the case of a large fire, but when a high or extreme rate of spread is present on a small fire, and a few men are involved, it is a matter of immediate concern and dictates whether the fire is able to be controlled within standards.

Policy

It is Forest Service policy to attack a fire when it is small and control it while it is small. In pole stands, this usually means a ground fire or an occasional flare-up in a thicket when ground fuels are heavy.

I would not say that the Forest Service will have this policy forever, but until the basic fire factors of fuel and weather can be better controlled, it would not seem prudent to let the small fires become large and attempt to control all of our fires after they become large.

Table showing comparison of factors relating to rate of spread in thinned and unthinned areas.

Factors	*Thinned Area Fuel*	*Unthinned Area Fuel*
Fuel, moisture content	Dry	Green
Fuel, density	More Compact	Spread over more space
Fuel temperature	Higher	Lower
Wind	Less restricted	More restricted
Air temperature	Higher	Lower

Assuming, then, that we are going to attempt to control fires when they are small, let us look at the basic change in fuel and environmental factors caused by saw thinning. Let us try to visualize 10 acres of Ponderosa pine (saplings), flat ground, 4,000 stems to the acre, no fuel on the ground except light needle and duff cover.

The table lets us compare just those conditions we change by the act of thinning.

All these factors show that a fire will start much more readily in dry slash. Therefore, the risk of fire is increased considerably.

In looking at the rate of spread factors, I think most foresters would agree that dry fuels burn better than green fuel, that the compacted position permits greater fire intensity, and that ignition is more rapid and the fire burns hotter in an environment where higher temperatures and wind are permitted.

The resistance-to-control factors are based on fighting a small fire, and the jackstraw position of the thinned material creates a difficult job in constructing a line by hand, even with a powersaw. Constructing a hand line through a pole stand with the fire on the ground is much faster and easier.

A Shortcoming

A serious shortcoming, in my opinion, in making decisions relating to slash disposal has been the constant reference to the relationship of the new hazard to the old hazard. You continually hear the argument that the stand was a serious

Figure 2—Area treated with mechanical brush cutter.

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fire hazard before the silvicultural operation, so why are fire people worried about the new hazard. This philosophy is comparable to the fellow who buys a houseful of termites and because they have been there for years, he doesn't believe it is necessary to eliminate them now. A common question asked is: Would you rather fight fire in a dog-haired thicket or in a thinned stand? The question is academic. My answer is that I would rather not have to fight fire in *either* situation. It seems to me that it ought to be National Forest management's objective to take steps to insure the lowest calculated risk of having serious large fires in stands where we have invested many dollars per acre.

This risk can be lowered at a reasonable cost by treating the slash in order to give us a rate of spread and resistance to control in which a fire can be controlled within policy standards.

The results of one slash treatment method are shown in the photograph below. (5)

Chemical thinning and machine swamper burning are other ways in which to reduce the hazard.

I think we should consider what problems develop and base our decision on the situation as it exists. If a Region is considering thinning fifty to a hundred thousand acres or more, the created fuel types of HH rating or above cannot be reasonably protected. The manpower, equipment needs, and costs to control fires in these fuel types within present standards would be exorbitant. At the same time, the risk of losing these stands would be very high.

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Obviously, then, under present costs, computer dispatching is feasible, but just not practical. But remember, our prototype system is unrefined and includes what might be termed research and development costs.

WHAT WE DO NEXT

We plan to continue the development of the prototype dispatch system in the following ways:

- Improve programing — we have the means to reduce the number of operations, amount of storage space, and time required for the computer to respond.
- Take advantage of the well-established trend toward cheaper, more efficient computer hardware.
- Try out other display systems, such as television screen cathode ray tubes.
- Develop a recommended dispatch model based on parameters of fire spread and fire control force capability. (This model would recognize the serious problems present in developing suitable economic criteria for fire control effort.
- Improve the road system graph to include the differences between classes of vehicles, such as pickups, fire trucks, and bulldozer transports.
- Develop a dispatch model that will weigh the cost of suppression against the values protected.
- Try the system in an area with a different pattern of fire occurrence and fire control resources than the San Bernardino Ranger Unit area.

Although we designed the system for initial attack, most observer interest has been for region or area-wide support dispatching. In many ways the system can perform this task much easier — time requirements are not so severe because travel times are longer, and the computer can be a greater help to dispatchers who cannot become intimately familiar with large geographical areas.

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Firebreaks Of Many Uses

HAMLIN L. WILLISTON [1] AND R. M. CONARRO [2]

Permanent firebreaks help protect large, highly flammable plantations while serving an important role in transportation, recreation, and wildlife management. These firebreaks are a cooperative effort of private landowners and government agencies.

Permanent travelable forest firebreaks are necessary to forest fire prevention and suppression on the Yazoo-Little Tallahatchie Flood Prevention Project in north Mississippi.

During the last 4 years, 1,207 miles of firebreaks have been built to help protect the 500 thousand acres of highly flammable, privately owned pine plantations established by the Project. They won't stop a "hot" forest fire without manpower assistance, but they do provide:

a. Quick access for fire suppression (fig. 1).

b. A base for backfiring.

c. A green barrier to slow winter fires.

d. Ways for harvesting forest products.

e. Ways for multiple-use management of the forested property.

f. Winter game food where conditions permit it to grow.

Cooperative Effort

Building firebreaks has been a cooperative effort among the landowners and several government agencies within the Project area, and other organizations may benefit from our experience and guidelines. The landowner must want firebreaks enough to cooperate in their maintenance and to permit the Mississippi Forestry Commission to use them in controlling fires on his or adjoining land. The Soil Conservation Service helps in planning, seeding, and fertilizing. The Forest Service helps in the planning, flags out the rights-of-way, finances some of the land clearing cost, and supervises their construction. The Agricultural Stabilization and Conservation Service provides partial financing, generally about 50 cents per 100 linear feet. The Mississippi Forestry Commission will contract with the landowner to do disking, light clearing, and some ditching.

The effectiveness of a firebreak system depends upon thorough planning. Our plans cover not only an entire ownership but also several adjoining ownerships. (We have firebreaks that extend 6 miles across 17 ownerships.) Planners concentrate on a system that is economical to construct and to maintain and yet is completely serviceable. Good use is made of the old woods roads that abound on the ridge tops in this area. Often rights-of-way for power, pipe, and telephone lines—providing written permission can be secured—are utilized.

In planning, due weight is given to past fire records, management needs, direction of the prevailing winds, topography, and access roads to the system and property. In scouting the route selected from aerial photos, the terrain, condition of the soil, forest canopy, on-the-ground flammable material, and other fire hazards, logical timber harvesting routes, recreational possibilities, potential wildlife openings, natural man-made barriers, and fences are all considered. Routes are chosen to avoid cutting pole-size or large timber and to avoid installing ditches and cross drainages. Steep grades, sharp curves, bogs or marshes, and live stream crossings are avoided. Truck and tractor

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Figure 1—Firebreaks have made many areas that could be reached only on foot easily accessible to fire crews.

turnaround space is provided at dead ends and at about one-half mile intervals along the break.

Cost Sharing

To qualify for cost-sharing under the local ACP Program, the area protected must have a stocking of at least 50 percent desirable stems, and the firebreaks must be located to contribute directly to the protection of the area. Breaks should be 15 feet wide. No part of the breaks will be less than 10 feet wide. The breaks may be located along property lines and throughout the area, but no more than 5 percent of the woodland area may be in firebreaks. The firebreaks must accommodate truck traffic. Lead-off ditches and water bars must be constructed where erosion hazards are created.

Where side ditches are needed, their required space is in addition to the designed traveled width. Where cross drainage is required, the firebreak is widened slightly for a distance of about 20 feet on the high side to provide better protection for the cross drainage entrance.

Firebreak clearing in stands of trees 3 inches and larger in diameter is generally done in the summer using a d-6, or equivalent, tractor and blade. This clearing job can usually be contracted at less cost than hand operations. The maximum distance between surface drainage should be 500 feet where the grade is 2-5 percent; 300 feet where the grade is 6-10 percent. Grades up to 15 percent may be used if their length does not exceed 100 feet. A lateral grade of 3-5 percent is best. Avoid areas with no lateral grade or with lateral slopes of over 10 percent.

Build side ditches only where necessary to drain permanent seeps. Use cross drainage to prevent water from rushing on or across the firebreak. For cross drainage, install an open ditch with rounded edges at an angle of 60 degrees to the center line of the road. This prevents both front or both rear vehicle wheels from being in the low or high part of the cross drainage at the same time.

Soil Cover

To be effective, a firebreak should provide, in addition to a travel way, a soil cover which will be green and non-burning during the winter forest fire months, October 15 to May 15. Seedbed preparation—disking, liming where needed, and fertilizing—should be started in the summer and completed by September 1. Wait at least 30 days before seeding, longer if the weather remains dry. Complete the seeding not later than October 15.

Kentucky fescue (*Festuca elatior* var. *arundinacea*) is one of the main winter plants sown, but it needs renovating after 3 or 4 years. It is a heavy user of nitrogen, phosphate, and potash and requires a pH of 6.0-6.8. White clover, (*Trifolium repens*) or winter peas can be grown in combination with fescue. Fescue needs a moist, well-drained soil and some sunlight for good establishment and growth.

Rye grass (*Lolium multiflorum*) is an annual which will quickly protect the soil. Rye should be used in combination with small grains such as winter wheat (*Triticum aestivum*) and winter peas (*Lathyrus hirsutus*) or with crimson clover (*Trifolium incarnatum*). The seedbed should be cultipacked after seeding. It generally requires two tons of lime

per acre. Rye grass combinations need a light soil disturbance each summer if permitted to go to seed.

Common Bermuda grass (*Cynadon dactylon*) is widely used in open areas in Mississippi. Only firebreaks constructed in areas open to grazing and not shaded should be seeded to Bermuda. Common Bermuda will produce better growth if it is mixed with legumes such as crimson clover, white clover, or winter peas.

Game Management

Many landowners are interested in managing for game as well as timber. Game food plots, not to exceed one-half acre, can be located along firebreaks and sown with the same cover. A scattering of food-bearing plants, if available, should be left on the plots. Mast-bearing trees surrounding the plots should be stimulated to produce bumper food crops by fertilizer applications. A fringe of common lespedezas, reseeding cowpeas, and wild soybeans can be seeded on the plots. Browse plots for deer can be located on the poorer timber sites. Such sites should be cleared of standing trees with the principal objective being to grow a heavy stand of fast-growing sprouts.

Many legumes may be found growing wild near firebreak locations. They provide winter food for quail. Legumes such as rattlebox, wild sweetpea, butterfly pea, and Japanese clover will grow under some shade and may be seeded outside the edges of the firebreak to provide winter food. Blackberries and mulberries are favored quail food and can be grown under partial shade (fig. 2). Common lespedezas, reseeding cowpeas, and wild soybeans provide excellent quail food and are easily established.

Cost

The cost of firebreak construction has run from $60 to $250 per mile averaging about $90. Increased accessibility to their property alone has more than compensated most owners for their investment. Started to protect young flood-control pine plantations, this practice has fitted effectively into a multiple use of land management program. Firebreaks have stopped many slow winter fires and have enabled the State fire crews to quickly get into the "back country" to suppress hot fires. Firebreaks are also being used for pulpwood operations, hunting, access to lake sites, and motorbike and horseback riding trails. △

Figure 2—Quail hunting is excellent along many of the firebreaks.

DISPATCHING, FROM P. 10

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U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

OFFICIAL BUSINESS

POSTAGE & FEES PAID
United States Department of Agriculture

Crawler Tanker-Plow

NICHOLAS LYLO AND
STUART HANNY [1]

The International 500 crawler tractor with a Seico fireplow attached for building fire lines is becoming an important firefighting tool in Pennsylvania. Seven of these machines are in use in the State.

Experience has shown that the addition of a small water supply and a light-weight pump add a safety factor for both the operator and the machine. The personnel of Michaux Forest District of the Department of Forests and Waters tackled the problem of developing such a unit. Their efforts produced the Crawler Tanker-Plow.

Features

The Tanker-Plow unit must have several distinct features:

1. It must be compact, have a water carrying capacity and a method of dispersal.
2. Any modification or additions to it must not interfere with the normal operation or maintenance of the tractor.
3. It must be constructed so that the weight is properly balanced.
4. The Tanker-Plow unit must be easy to assemble.
5. It must be dependable and easy to operate.
6. The cost of conversion must be reasonable.

All these desired features have been incorporated into the Crawler Tanker-Plow (fig. 1). The unit developed by the Department has a water carrying capacity of 62 gallons in a Snyder fuel step-tank. This water can be dispersed either by hand through the use of a backpack tank or mechanically through the use of a gasoline operated pump. To make the unit complete, a tool box was installed to carry small hand tools necessary for minor field repairs. A drip torch for backfiring and burning out the line was mounted on the unit, and a single bit axe was attached on the back of the cab. A light was mounted on the rear of the tractor for night operation. The Crawler Tanker-Plow is complete, compact, and very usable.

The installation of this equipment on the tractor was accomplished without altering the primary purpose of the tractor plow. Normal operation of the vehicle is maintained by simply extending and relocating the control handles and using the tank step as a seat. The weight is balanced by adding counterweights or installing a blade on the front of the tractor. The photographs show that the additions in no way interfere with tractor maintenance. Anyone with some mechanical ability can make the conversion by following plans available from the Pennsylvania Department of Forests and Waters.

Cost

The cost of materials is small in comparison to the overall advantages of the unit and can be purchased for less than $275.00. Labor cost depends on the ability of the person who assembles the unit. Using a skilled mechanic, the cost of assembly and installation should be less than $150.

With two methods of water dispersal, an assortment of hand tools, and a drip torch, this unit is very dependable and has become an important part of firefighting equipment. It provides protection for the unit and operator and provides a water supply in areas inaccessible by other methods.

Plans and parts lists are available from the Pennsylvania Department of Forests and Waters, Michaux Forest District, Route 2, Fayetteville, Pennsylvania 17222

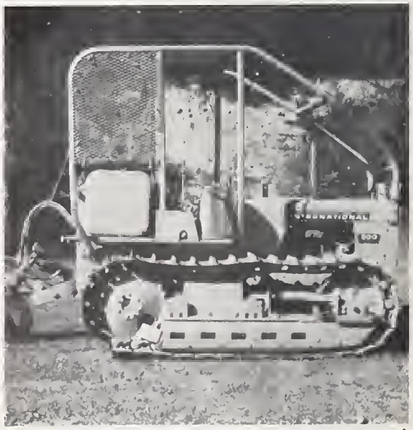

Figure 1—Crawler Tanker-Plow showing end of 62-gallon tank, faucet for filling water cans, coiled discharge hose inside cab grill, and backpack pump.

[1] Lylo, Assistant District Forester; Hanny, Forest Technician; Michaux Forest District, Pennsylvania Department of Forests and Waters.

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FIRE CONTROL NOTES

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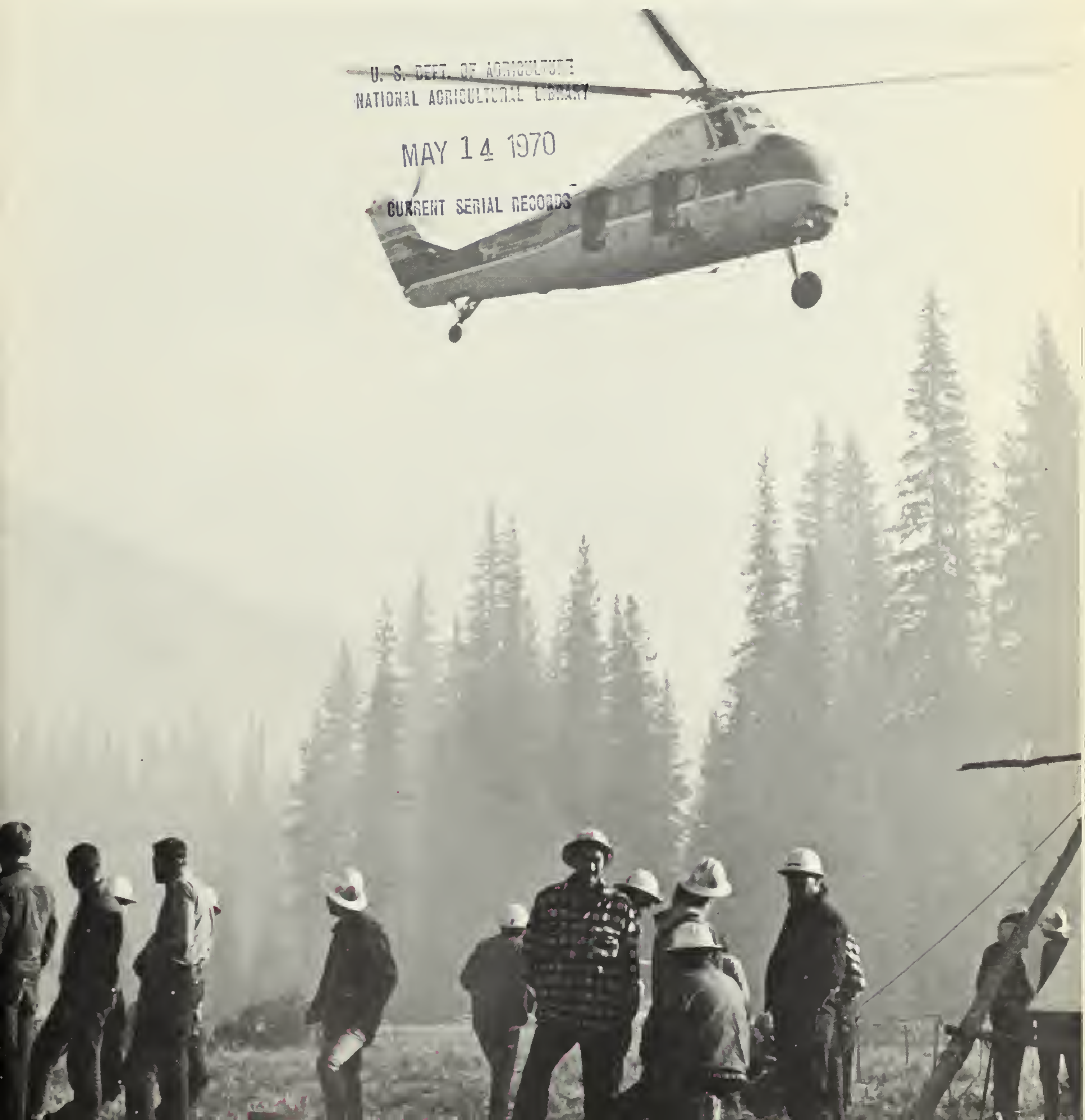

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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Liquid Fertilizer Tested As Fire Retardant

WILLIAM C. WOOD[1]

Liquid Concentrate (LC) fertilizer (10-34-0) as a fire retardant has been given field evaluation by the Forest Service in the Pacific Northwest Region. There appear to be many advantages to use of LC over other retardants.

Faced with the prospect of a major expenditure in retardant plant overhaul, the Pacific Northwest Region made a survey to determine whether other long-term fire retardants might offer advantages over the standard retardant, ammonium sulphate slurry.

Fertilizer?

Pat Int-Hout, Fire Staff Officer of the Wenatchee National Forest, suggested that Tennessee Valley Authority's Liquid Concentrate Fertilizer (11-37-0) be considered. Liquid Concentrate is a syrupy liquid solution of condensed phosphates referred to in the fertilizer industry as polyphosphates. Polyphosphates, when exposed to the weather, tend to remain tacky and do not evaporate readily. Orthophosphate solutions such as DAP and water form salt crystals when dried.

Int-Hout's suggestion prompted a review of Forest Service fire research literature which indicated that nonviscous retardants have certain advantages over thick slurries. Of particular note was a Fire Control Notes article of April 1968, Vol. 26 (2): 13-16, written by R. W. Johansen and G. L. Crow, "Liquid Phosphate Fire Retardant Concentrates," which described convincingly the advantages of liquid concentrate retardant.

Contacts with the Southern Forest Fire Laboratory at Macon, Georgia, along with observations of the Southern Region's use of TVA (LC) 11-37-0, proved convincingly that Liquid Concentrate (LC) polyphosphate fertilizers should be evaluated for use as fire retardants. In fact, a survey of the Southern Region's air tanker base operations revealed that the mixing and handling advantages of LC over slurries are profoundly in favor of the liquid retardant.

First Step

First of all, a prospectus to obtain information on the cost and availability of LC polyphosphates was prepared and circulated throughout the fertilizer industry in Oregon and Washington. From this, it was learned that TVA's (LC) 11-37-0 required excessive delivery time and was not commercially available in the State of Oregon. LC 10-34-0 was readily available throughout the Pacific Northwest at a cost about 25 percent below the TVA product. Approximately 1,500,000 gallons of LC 10-34-0 are stored in Oregon and Washington agricultural areas.

LC 10-34-0 was selected for operational field trials. The main difference between 11-37-0 and 10-34-0 is that 11-37-0 is more concentrated. Since it is slightly weaker, less water is added to the 10-34-0 concentrate to produce an approximate 8 percent phosphate equivalent solution. Research by the Southern Forest Fire Laboratory indicates that an 8 percent phosphate equivalent will effectively retard fires in most forest fuels. An approximate 8 percent phosphate equivalent has been successfully used by the Southern Region for the past several years.

Field Test

For the field test project, one gallon of LC 10-34-0 was blended with 4 gallons of water to give an 8.7 percent phosphate equivalent solution. One gallon of mixed solution costs about

Figure 1.—P2V dropping 1,000 gallons of LC retardant from 200 feet.

[1] Equipment Specialist, USDA Forest Service, Region 6.

$.12. The corrosion inhibitor, sodium dichromate, in the proportions recommended by the Equipment Development Center at San Dimas is included in this cost. By comparison, ammonium sulphate slurry costs about $.17 per gallon.

The Wenatchee, Wash., and Lakeview, Ore., air tanker bases were each outfitted with a storage tank and a meter to accommodate LC. The provisions were relatively simple: the LC storage tank and the water line were each valved and piped into the suction side of a 300 g.p.m. centrifugal pump which discharged through a fire hydrant meter into the aircraft loading hose. Original batch mix facilities were left intact; thus, each base could furnish both slurry and LC.

In spite of the relatively light 1969 fire season in the Pacific Northwest, 117,000 gallons of LC retardant were dropped on 28 fires by air tankers working out of Lakeview and Wenatchee. Evaluation reports by air attack bosses were completed for all drops, and, in addition, about 75 percent of these fire drops were evaluated by ground forces.

Figure 2.—Three-inch fire hydrant flow meter with quick-connect fittings installed between pump discharge and loading hose.

Compared With Slurry

On a number of fires, slurry and LC were dropped side by side. This gave fire research scientists and fire bosses a good opportunity to observe the comparative effect of each on wildfires. Personnel from the Southern Forest Fire Laboratory assisted in the evaluation. From comments of ground personnel and an analysis of evaluation reports, it emerged that LC is at least equal, if not superior, to ammonium sulphate slurry in holding and stopping fires.

The majority of fires occurred in pine-brush and pine-juniper-mahogany areas. However, several drops were made in grass-sagebrush, in coastal Douglas-fir, and on fires in pine and Douglas-fir slash units.

In all cover types, ground crews reported that more LC than slurry got through to the ground, and the cooling effect was more pronounced from LC than from slurry. Perhaps this was due to the temporary increase in humidity and smothering effect of vaporized LC. The LC appeared to have a more lasting effect and seemed to draw moisture from the air overnight. LC retardant deposited on fuels remained moist and tacky for several days after the drop, whereas the slurry dried completely after a few hours' exposure to sun and wind. Knock-down effect on crowning and running fires was more pronounced, and rekindling was delayed longer. Sections of fireline treated with LC required less crew holding action than those with slurry. With "High" fire-danger ratings and winds up to 15 m.p.h., several running and crowning fires in pine types were stopped completely with LC. On three running fires in heavy fuel, neither retardant was effective.

Ground Coverage

The area of effective ground coverage from LC was almost twice as large as that obtained with slurry. LC patterns were consistently longer and nearly twice as wide. There appeared to be more uniform distribution of LC over a wider area while the thick slurry (1600-2000 centipoise) patterns tended to have large puddles and unequal distribution. Comparative drops, made later with the P2V Neptune on the Medford Airport, confirmed the increased pattern size of LC (fig. 1). The drop cloud of LC in descent resembled a heavy, swirling rain. The swirling effect apparently caused more complete coating of fuel. Examination of vegetation in LC patterns showed that standing grass, leaves, needles, and brush were usually covered on all surfaces.

Ground crews who left hand tools in the vicinity of drops where they were inadvertently sprayed with LC reported that handles became sticky and had to be rinsed. No toxic reactions were noted, but it was reported that minor cuts and abrasions would sting when exposed to LC spray. This is also true of slurry.

Air Personnel Opinion

Air tanker pilots and air tanker bosses reported no appreciable differences in piloting techniques with LC. One slight advantage is that the area covered on the ground is larger. Flight elevations above the ground and safety precautions to avoid injury to ground crewmen are the same.

Daily washdowns of aircraft, which are needed to minimize corrosion effects, are far easier when LC is used. LC is more soluble than slurry and is easily removed with low-pressure washing. No special modification to aircraft tanks is required except that gasketing must positively seal all compartments, bolt holes, and seams. Tanks which would hold slurry reasonably well leaked badly when filled with less viscous LC. Usually, each air tanker on standby was loaded to one-half capacity with plain water. Upon receipt of a fire call, the required amount of LC was pumped into the tanks and the remaining quantity of water was then added to fill out the load. This speeded up loading time and also flushed the pump and meter each time the aircraft was loaded. All contract air tankers in Region 6 have internal manifolds which provide for equal mixing of the LC and water in each tank compartment.

Long-Term Effects

The long-term accumulative effect of LC corrosion on mix plant hardware is unknown, but it is expected to be much less than that experienced with slurry. An analysis of mix plant operations, made by the Fremont National Forest, showed the man-hour production rate of the LC plant was more than 10 times greater than slurry. Two men can handle an LC plant during peak activity, while six to eight men are required to sustain a slurry operation. One man can handle an LC plant during routine activity. An additional advantage is that the meter provides a positive measure of the quantity of retardant loaded into the aircraft (fig. 2). Metering of slurries has been considered impractical.

Dye Marker

The LC used last year did not contain a dye-marker. It was decided to try to identify targets and dropped loads by means of a Flagmaster, a device which flips signal streamers off the wing of the lead plane. This was only partially successful. Although the field trial was completed without the benefit of a dye, it became obvious that LC should contain a dye especially for situations where multiple drops are made by different aircraft on several fires in close proximity. Commercial suppliers have indicated that they are prepared to furnish LC with a premixed coloring agent.

On the basis of the 1969 tests, it has been decided to convert all Region 6 air tanker bases to accommodate LC retardant. Existing stocks of slurry mix will be used up and mix plants will be converted as funds permit. Plans call for installation of mix plants similar to those used to blend liquid fertilizers in agriculture. △

Sector Camps Improve Fire Force Efficiency

BRIAN SCHAFFER[1]

The use of small sector camps, supplied by helicopter and/or roads, increases efficiency of crews. Reduction of hazard to crew safety is also an important result. An example of manning and supplying three sector camps by helicopter is given. It illustrates a feasible procedure.

The traveling distance from fire camp often results in extremely long work shifts. Shifts required by long travel times place unnecessary strain on the firefighter, and after a few days, his ability to perform adequately and safely is sharply reduced.

[1] Supervisory squadleader, North California Service Center.

Figure 1.—Firefighters scrambling for a helicopter lift to the fire.

Long traveling distances not only tie up men and equipment, they put a heavy load on plans and service operations. They also increase the accident risk for both men and equipment.

All these problems were observed in 1968 on the Liebre Fire, Angeles National Forest. The trucking route from fire camp to the unloading points was on a narrow, steep truck trail and took well over an hour, one way. As a result, the average work day was 18 hours, and one work day was 20 hours. The establishment of sector camps supplied either by air or truck would have eliminated unnecessary travel time and allowed the firefighters more time for rest in between shifts.

If a sector camp could be reached by road, the men required for day and night shifts could be trucked there initially, left, and supplied by truck until ready to come out. If the sector camps were inaccessible by road, they could be manned and supplied by helicopter. If copters aren't available for both manning and supply, fixed wing aircraft could be used as supplying vehicles. If there were a shortage of aircraft, the men could walk to their sector from the nearest road and remain there until the work is complete. Zone and forest fire caches could prepare sector drop camps in units of either 50- or 100-man camps. Several of these units could be prepared before the fire season begins.

Helicopters

If helicopters are used, each camp should have one assigned to it after the initial manpower lift. Helitack foremen would make ideal helicopter managers for this type of operation. They are already trained for loading and unloading 'copters and selecting safe helispots.

The sector camp should have a number for identifications placed near the helispot or cargo drop point. This number can be made from ground-to-air panels or paint spray cans. When sector camps are to be supplied by 'copter, sling loading is the most efficient and time saving method.

Two or three men could be responsible to the day sector boss for setting up each camp and heating two frozen meals per day. The use of frozen meals will eliminate the need for trained cooks at each camp. Lunches could be prepared by a catering service or base fire camp and flown in.

By assigning men to a sector, leaving them there until the work is complete and supplying them by air or truck, the need for long and sometimes arduous periods of travel between fire line and fire camp can be eliminated. Only safe

areas should be selected for the camp location, however.

Rest Helps

More time for rest between shifts will decrease the accumulative fatigue factor and the accident risk. The risk of motor vehicle accidents on traffic-jammed truck trails will be reduced. Plans and service operations will be simplified. Gains will include more productive working time on the line, higher morale of the men, increased productivity on the fire line, and increased safety.

Whenever the driving time from fire camp to sector exceeds 30 minutes, the establishment of sector camps should be considered. The fire boss may want to keep one or two hot-shot crews available at the base fire camp for trouble-shooting hot spots or working the head of the fire. The concept of air manning and supply is flexible enough to handle most situations that arise. The keys to its success are training, planning, organizing, and coordinating.

A Sample Problem for Manning and Supplying A Three Sector Fire By Helicopter

Assume 100 men per sector and at least seven light turbine helicopters available initially. Helitack crews under supervision of the service chief or line boss should have already selected and completed construction of sector camp helispots. During the initial air lift, two light turbine copters (Hiller 1100 types), or one large one (Bell 204 B, 205 A), should be assigned to each spot. After the men and fire camps have been transported to their sectors, one helicopter per sector camp will be sufficient to bring up daily supplies and for necessary crew movement within the sector. The day shift should be lifted first and early enough so that the fire camp can be sling-loaded up next. The fire camp can then be set up by a few men while the night shift is being brought in. Two men are enough to heat the steamed meals and manage the camp.

The helicopter manager's job during this type of operation will require close coordination with the air attack boss, line and sector bosses, and the plans and service chiefs. When there is an air tanker operation going in a certain sector, the helicopter operation in that sector can be suspended temporarily and that sector's 'copters assigned to speed up the air lift to other sectors.

Daily Supply

Water: The minimum water necessary is 2 gallons per day per man. Our drop camp supply sheet lists the weight of water with containers as 90 lbs. per 10 gallons. One hundred men will require 1,800 lbs. of water or about two to three sling loads. Loads or trips for water can be reduced if water is brought up during other routine missions.

Food: One frozen food company lists the weight of a 10-meal box of supper meals as 20 lbs., and 10 breakfasts as 18 lbs. The total for one day's meals for 100 men comes, then, to 580 lbs. Food for the day can be brought up in one load, early in the morning, or brought up late afternoon for the next day.

Additional supplies: Replacement tools and other necessities can probably be brought up during some of the routine missions during the day.

Additional Pointers

1. *Cost*—The average cost per man to fly to his sector camp is about $15.00 per 5-mile flight.
2. *Aircraft*—It would be advantageous to have at least two aircraft per sector camp available for the initial air lift. The extra helicopter per camp can be released after the air lift.
3. *Density Altitude*—When operating at extremely high temperatures and/or elevations, the density altitudes can be high enough to considerably lower the freight loads. There are no hard and fast rules as to what the helicopter can carry. Payloads depend on environmental conditions. The pilot has to make the final decision.
4. *Tooling Up*—When the men arrive at base camp, they should each be issued a tool and a gallon of water. They should keep their fire bags with them (fig. 1). These items should be airlifted with the men. There may be times when one man has to be dropped from a load due to density altitude. Files, headlights, batteries, and paper sleeping bags are included in the drop camp.
5. *Breaking Camp*—When the work is completed in a sector, the men can either be flown out or walked out. The drop camps can be sling loaded in two trips per 50-man camp.

△

Oscillating Sprinklers Backup For Burnout

JOHN D. DELL[1] and
GEORGE I. SCHRAM[2]

An oscillating sprinkler system serves effectively as a backup for burnout. It was used on the Eagle Rock Fire, Willamette National Forest, in 1967 to hold a difficult section of control line near the bottom of a V-shaped canyon where radiant heat was a major concern.

A fireline is not complete until the unburned fuel between the fire edge and the control line is reduced or eliminated—usually by burning out. This operation is a routine part of the fire suppression job—unless the burnout must be done under conditions of adverse topography, wind changes, or heavy fuel concentrations. In this event, the operation is usually reinforced with extra holding crews and equipment, air drops of chemical fire retardant, or both.

Oscillating Sprinklers

An oscillating sprinkler system was used effectively as a backup for a difficult burnout on part of the 1,300-acre Eagle Rock Fire on the Willamette National Forest, western Oregon, in 1967. This same sprinkler system, and its application for slash burning, has been described by Orr and Dell.[3] It is now assembled in kit form for easier transport and handling. The kit (fig. 1) weighs about 175 pounds. It has 20 galvanized steel conduit standpipes, 20 sprinkler heads, and accessory hardware for connection to a 1½-inch fire hose. Cost of parts for the 1,000-foot, 20-unit system is about $350, and it takes about 2 man-days to assemble it. Assembly instructions, equipment list, and sources for parts supply were reported by Orr and Dell.

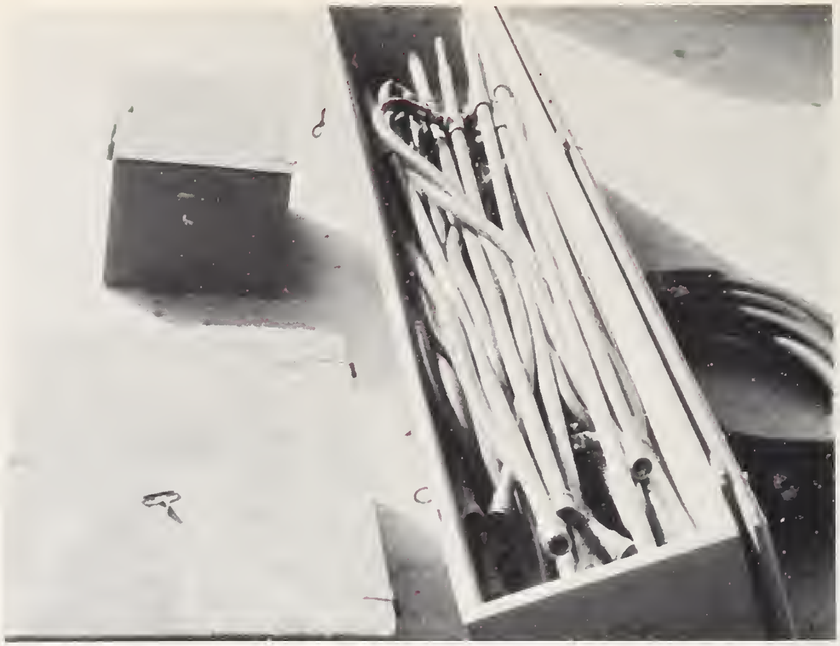

Figure 1.—All equipment for 20 sprinkler units is assembled in a kit for easy transport and handling.

Eagle Rock Fire

The situation at the Eagle Rock Fire required burning out more than a quarter mile of critical control line. This line was near the bottom of a "V"-shaped canyon (see fig. 3). Fire control was difficult because the topography included numerous steep cliffs and rock outcroppings. Use of tractors for line construction was impossible. Although the control line for the burnout was in a difficult location, it was the best that could be found—the line was as close to the fire's edge as a crew could work. If it had been necessary to build this line at the nearest natural topographic break, at least an additional 100 acres of timber and watershed valued at $15,000 might have had to be sacrificed in the control effort. A 50-foot path on the fire side of the control line was cleared of smaller trees, brush, and standing snags. Most of this debris was deposited in the bottom of the draw. Ignition of outside fuels by radiation from the burnout was a major concern.

Water Supplied by Ground Tanker

A thousand feet of fire hose was laid next to and just above the control line (fig. 2). The sprinkler kit was unloaded at a roadhead, and unit components were carried or placed in backpacks for transport by the

[1] Forester, Pacific Southwest Forest and Range Experiment Station, stationed in Portland, Oreg.

[2] Fire control technician, Sweet Home District, Willamette National Forest, Sweet Home, Oreg.

[3] Orr, William J., and John D. Dell. Sprinkler system protects fireline perimeter in slash burning. Fire Control Notes 28(4): 11-12, illus. 1967.

assembly crew to the burnout area. Hose line fittings were placed at each 50-foot coupling, and the 20 oscillating sprinklers were connected to the line. Stream water was not available for the operation, so the water had to come from a 3,000-gallon slip-on tank on a dump truck, with a Pacific Mark 3 pump providing pressure. Four additional nurse tankers were used for resupply. Water was hauled 2 miles from the nearest natural source. Since the Eagle Rock Fire, we have determined that 20 full circle oscillating sprinklers ($\frac{5}{32}$-inch nozzle) on a 1,000-foot, $1\frac{1}{2}$-inch cotton jacketed-rubber lined (CJRL), hose-lay require a 4,500 gallon per hour water supply.

Burning out at Eagle Rock started late in the afternoon. Sprinklers were not turned on until burning was underway so that they could not adversely affect the firing. As firing crews progressed down the draw from the top, sprinklers were turned on behind them. The sprinklers were set on 180° rotations so that only the area outside the control line was wet down.

Sprinklers Assist Holding and Mopup

Heat from the burnout fires became intense, but no spot fires started in the areas covered by sprinklers. Holding crews were able to use the sprinkled area as a heat shield.

Firing was completed at 0200 hours the following morning, with fire in the upper sector of the line already diminishing. Sprinkler heads were readjusted to full circle, so that the burned-over area inside the line would be cooled off for mopup the next day.

Through the critical hours of the burnout, an estimated 40,000 gallons of water were used. In the opinion of the fire over-

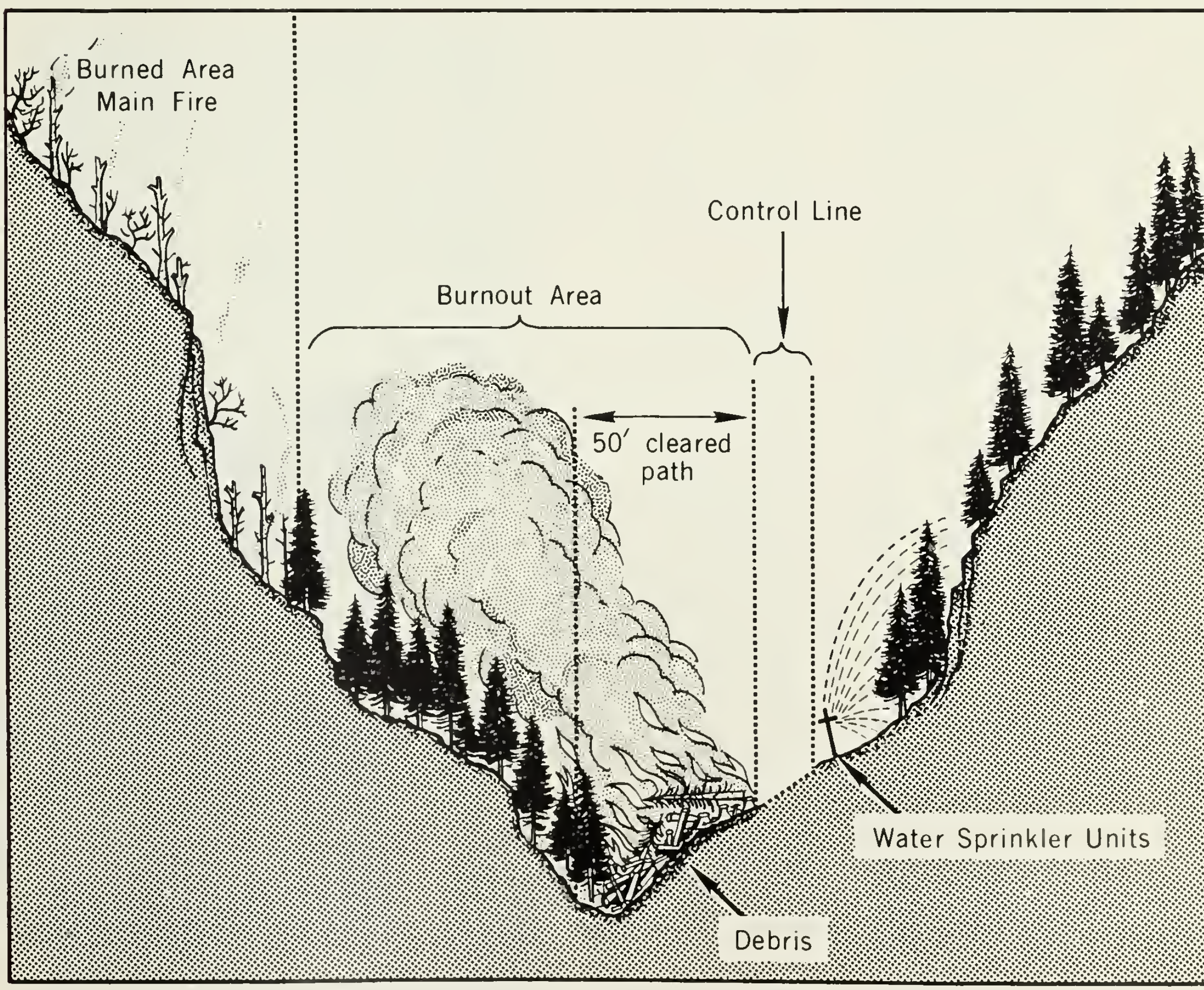

Figure 2.—In this burnout situation, a 20-unit sprinkler system was used to reinforce the fire control line in the 1967 Eagle Rock Fire. Clearing for a burnout control line resulted in a dense concentration of debris in the canyon bottom. The sprinklers, placed just above the control line, prevented spotting over the line from radiated heat.

head who observed the operation, the line could not have been held without the sprinklers.

Observations

The use of a sprinkler system can contribute to the fire control effort in both prescribed burns and wildfires. We believe the system has these specific advantages. It:

- provides an even, measurable (gal./min.) water diffusion over the fuel area to be treated.
- allows a sprinkler to be shut off anywhere along line to conserve water when it is not needed.
- allows connection of additional hoses and nozzles for covering spot fires across a line.
- can have a favorable effect on burning conditions within several hundred feet of the sprinkler line.
- generally conserves water supply because of low flow rate from small orifices on sprinkler heads.
- can be used to help protect special areas, such as recreation sites, plantations, buildings, and homes.
- can be used to reinforce narrow control lines.
- can be used to reinforce and wet grass-covered fuel breaks on fire perimeter.
- serves as a heat shield for line crews during holding, backfiring, or burnout operations.
- can be used in helping mop-up by gradually moving the system inward from the fire's edge.

The Eagle Rock Fire marks one of the few instances in the Pacific Northwest Region where sprinklers have been used on a wildfire. Improvements in some of the equipment and assembly methods we used can be expected. Distributing water by sprinklers offers excellent possibilities for conserving manpower and promoting safety in fire control work. △

Retardant Sacks Baled For Disposal

James C. Allen[1]

The disposal of empty retardant sacks has long been a problem around retardant bases. Methods vary from throwing the sacks on the ground or onto a truck or trailer to throwing the sacks directly into an incinerator for burning on the spot.

Disadvantages

Each of these methods has disadvantages. During periods of high fire occurrence, the entire area around the retardant mixing plant is covered with sacks when they are thrown indiscriminately on the ground. It is expensive to keep a vehicle on hand for carting sacks away, and air pollution restrictions have outlawed the use of the incinerator in many areas.

Retardant Plant Foreman Robert H. Mayfield designed a baler that was installed at the Redmond Air Center plant in 1968. It has since been adopted for Service-wide optional use. The sacks are now baled and stacked until they can be hauled away at the end of the day. A savings estimate of $10 per operating day in handling costs is realized from the use of the baler. Intangible benefits include: air pollution abatement, improved appearance of the plant, and better utilization of available working space.

Construction

The unit is constructed of 3/4" pipe (fig. 1) and includes a foot press and a latch to hold the press in place while the sacks are being tied. The sacks are tied with twine, and each bale consists of 25 sacks, one mixer load.

The cost of the unit was $46 for pipe, welding, and assembly. Scrap material was used for the foot press and other small parts. Pipe cutting and painting was done by the plant foreman in his spare time. Estimated cost to have the unit constructed by a commercial source is $125-150.

Plans

Plans are available from Forest Supervisor, Deschutes National Forest, 211 East Revere, Bend, Oreg. 97701 △

Figure 1.—The baler is conveniently located where slurry is mixed and empty sacks can be dropped in the baler. One mixer load of 25 sacks compresses into a bale of approximately 2' x 3', convenient to handle and neatly and easily stacked.

[1] Air Center Manager, Redmond Air Center, Deschutes National Forest.

162. We call it an EXPLOSION! This is why —

163. If you walk into a dusty place smoking a cigarette —

164. This can happen!

Structural Fire Prevention Training Pays Off

RICHARD R. FLANNELLY[1]

A trainee-oriented fire prevention program sharply reduced the number of structural fires at Forest Service Civilian Conservation Centers. The program contained a basic and a review course, as well as a self-contained course for staff members and advanced Corpsmen.

In 1966, the pace of establishing 45 Forest Service Civilian Conservation Centers was so hectic the potential problem of structural fires was not placed in the proper perspective.

These Centers are in isolated locations and must depend primarily on their own resources to suppress fires. By February 1967, 18 fires had occurred, resulting in a financial loss of $84,000. By phenomenal luck, no one was killed or injured. Safety experts say that whether or not a given exposure to accident results in no injury, minor injury, major injury, or death is merely a matter of luck. Our assumption was that we had just about run out of luck.

The Forest Service is noted for its prowess in preventing and suppressing forest fires but has limited experience with structural fires. For this reason, we decided to start a training program for structural firefighting and open this program to proposals from private training contractors.

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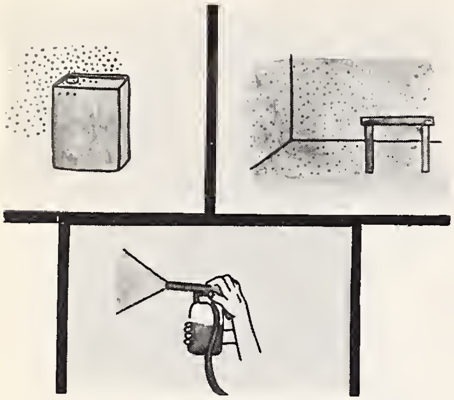
[1] Employee Development and Training Branch, Division of Personnel Management, Washington Office, USDA Forest Service.



165. Turn to page 2 and answer this question.

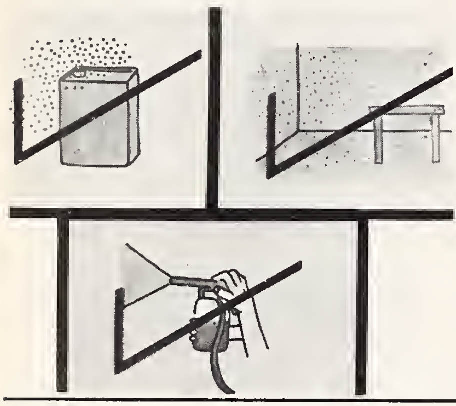
Where can a spark cause an explosion?

—A spark in a room of gasoline vapors.

—A spark in a dusty room.

—A spark in a room of paint fumes.

—ALL of these.



166. The answer is ALL of these. MANY kinds of dust, vapors, and fumes can explode.

TECO Instruction, Inc., of Atlanta, Ga., was awarded the contract. TECO staff talked with Corpsmen and Job Corps personnel, observed fire related behavior and attitudes, and attempted to determine common fire hazards at several Job Corps Centers.

Data collected outlined the differences between the Corpsman's actual fire prevention behavior and their desired behavior. The training program, then, had to be planned around the following constraints.

1. At least 40 percent of the Corpsmen in every Center have a reading ability below the third grade level.

2. Corpsmen's attention spans are short in the classroom.

3. The Center cannot use programs that require outside assistance.

4. Centers are limited in audio-visual equipment, and there are no provisions for purchasing new equipment.

The Training Course

Entitled "Structural Fire Prevention and Control," the training course consists of 1,014 color slides and 16 booklets. It is divided into three major units: The Corpsmen Basic Course, Corpsmen Review Course, and the Self-Contained Course for staff members and advanced Corpsmen. The Basic and Review Courses involve the use of 35 mm. color slides, instructor manuals, trainee response booklets, and demonstrations. The Corpsmen booklets contain pictures only—no words.

The instructional method in the Basic and Review Course includes classroom presentation and demonstrations. The instructor shows a series of slides while reading a prepared text from his manual. At key points, the Corpsmen are required to respond either orally or by checking in their response booklets. The following sample from the instructor's manual demonstrates this technique:

Insert Illustrated Frames

In frame number 3, the instructor tells the Corpsman which page to turn to in the Corpsman's answer book. The same picture appears in the Corpsman's answer book as appears on the screen. The Corpsman indicates his response by checking the picture.

The Basic Course covers seven subject areas by units:

A. Some Facts About Fire and Fire Safety.
B. Explosions and Fire Preparedness.
C. What To Do if Fire Occurs.
D. The Fire Triangle and the Fire Extinguisher.
E. What To Do if Fire Occurs—Some Special Cases.
F. Special Fire Hazards (Smoking, Clothes Dryer, and Electrical Appliances)
G. Other Fire Hazards.

During the Basic Course, fire demonstrations are provided that build on knowledge learned in the classroom. These demonstrations include Fire Plan Orientation, Hazard Hunts (each becoming more specific), Fire Extinguisher Practice, and Fire Evacuation and Rescue Practice.

The Review Course covers the same subject matter and demonstrations as the Basic Course, but with less detail and explanation. It was designed as follow-up and refresher training for Corpsmen.

The Self-Contained Course has the same content as the Review Course, but the printed

message is printed alongside the corresponding visual. The Self-Contained Course is for use by staff members and by Corpsmen who are advanced in reading skills.

The finished product was demonstrated to officials of the Interior Department. They decided to adopt the program in their Conservation Centers.

One Year Later

There has been a sharp reduction in fire losses since the program was initiated. Only two buildings have been lost and one damaged, and no injuries or loss of life were involved. All three fires were caused by arson, a problem which we knew about but did not believe could be prevented by a training course. But the lack of injuries may be traced to improved evacuation of buildings. Obviously, one training course cannot be given full credit for reducing fires or saving lives. A great amount of management attention was focused on the Center fire problem by adoption of the training, policy statements, and inspections.

The concern and involvement of management has been a critical factor in this program as it is in any safety or training program. Those Centers which had not implemented structural fire training listed lack of time as the primary reason. A manager must always weigh the investment of time for safety and training against the consequences of what may happen if he does not invest the time. In his safety role, a manager has to be accountable not only to the law but also to his supervisor, his subordinates, the total organization, and his own conscience.

We will never know the ultimate value of structural fire training because the effects should stay with a Corpsman long after he leaves the Center. The same fire prevention principles will apply equally as well in his home.

If you wish more information about this course, contact the Training Branch, Division of Personnel Management, Forest Service, USDA, Washington, D. C. 20250. △

LC Retardant Viscosity Reduced In Alaska

C. W. George,
R. J. Barney,
and G. M. Sheets[1]

More than 4 million acres of forest and rangeland were burned by wildfire in Alaska during the summer of 1969. Airtankers played a major suppression role by dropping more than 2 million gallons of viscous fire retardant chemical. Some of the numerous drops were investigated, and follow-up discussions with fire control personnel indicated that changes in the physical properties of the chemical solution might improve fuel penetration and coverage, thus enhancing suppression characteristics.

A preliminary evaluation of nonviscous liquid concentrate was undertaken to determine whether retardant effectiveness could be improved in the Alaskan fuels by reducing the viscosity and surface tension.

The Alaskan Study

Thickened ammonium phosphate (Phos-Chek® 202[2]) has been used to combat wildfire in Alaska for the past several years. An evaluation of drops on wildfires during July 1969 near Fairbanks indicated fuel coverage and penetration were not complete. The slurry effectively coated spruce, birch, aspen, and associated aerial fuels but exhibited limited penetration into heavy ground fuel. (Slurry samples taken had a viscosity of 1500 centipoise and diammonium phosphate salt content of nearly 12 percent by weight.) This coverage was effective in halting the rate of spread through aerial fuels. Although flaming combustion was sometimes extinguished for as long as an hour, the retardant did not prevent smoldering and glowing which continued beneath and through the treated fuel.

Penetration and coverage by Phos-Chek 202® can be improved by lowering the viscosity of the solution or possibly by adding a wetting agent, but not without a concurrent decrease in the salt content. Thus, use of nonviscous liquid ammonium phosphates is an approach which can improve application characteristics without impairing the salt concentration.

The following liquid concentrates, which had demonstrated desirable characteristics in preliminary laboratory tests at the Northern Forest Fire Laboratory, were also evaluated for Alaskan use:

1. Fire-Trol 930[3] (liquid 10-34-0 manufactured by Allied Chemical Corporation and containing 1.5 percent by weight $Na_2Cr_2O_7$ as a corrosion inhibitor).

[1] Respectively, research forester, Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station, Missoula, Mont., project leader, Pacific Northwest Forest and Range Experiment Station, at the Institute of Northern Forestry, College, Alaska; assistant fire control officer, Bureau of Land Management, Fairbanks, Alaska.

[2] Phos-Chek® 202 is a product of the Monsanto Company.

2. Fire-Trol 934[3] (Fire-Trol 930 with a surfactant or wetting agent added).

The limited amount of liquid concentrate available (enough to mix 6,000 gallons of retardant solution) allowed only a few airdrops of Fire-Trol 930 and 934. Both materials were evaluated, however, using Phos-Chek 202® drops as a basis for comparison. All retardant drops during the tests were made from a PB4Y2, capable of carrying 2,500 gallons in eight individually gated tanks.

By opening two gates together, 625 gallons could be dropped; to stretch the limited supply of liquid retardant, a 500 or 1,000 gallon drop size was used. The drops were made from as close to 100 feet (tapeline altitude) as possible at a speed of between 110 and 120 m.p.h., in winds of less than 5 m.p.h.

The retardant was dropped on uncontrolled fire fronts in the Fairbanks area when conditions and logistics were favorable. The evaluation was made by teams both in the air and on the ground at the time of the drop. The duration and extent of effectiveness for each drop were noted. The date, size, and number of drops evaluated are given in table 1, with the chemical analysis of each retardant.

[3] Fire-Trol 930 and 934 are marketed by Arizona Agrochemical Corporation.

Results

Apparently the three retardant solutions where the Fire-Trol 930 and 934 stopped the fire, Phos-Chek 202® acted as a suppressant also. Where both liquids failed or only reduced the rate of spread, Phos-Chek 202® had similar effects. Where none of the three was successful, the spread could be attributed to flaming or smoldering through unpenetrated or uncoated fuel. Where ground fuels were heavy and tussocks numerous, all retardants were ineffective.

Drop patterns for the unthickened 930 and 934 were similar though larger than those for Phos-Chek. Under the drop conditions described elsewhere in this article little difference in the effective pattern area could be resolved. Fire-Trol 930 and 934 dispersed and more uniformly coated aerial and ground fuels. Phos-Chek tore up turf and broke trees, but little evidence of Fire-Trol 930 and 934 impact was apparent.

Discussion

The low viscosity of the liquid retardants (less than 50 centipoise) did not hamper their effectiveness. This was attributed to:

1. Drops being made from 100 feet or less (tapeline altitude), made possible by relatively low canopies and smooth terrain.

2. The largest percentage of the drop ending up on ground fuel. Normal fire spread was through ground fuels, although crowning of individual trees far behind the flame front sometimes contributed to fire spread by spotting. A thick retardant coating on aerial fuels was not necessary.

3. A 30-percent higher salt content in the liquid retardant (nearly 8.5 percent compared with 6.0 percent P_2O_5 equivalent for Phos-Chek). Greater dispersion and less solution retained on fuels could be tolerated, yet an effectiveness equal to that of Phos-Chek would still be maintained.

The only noted disadvantage of Fire-Trol 930 and 934 used under these conditions was lack of color. These unthickened solutions were not visible to the pilots and made tying together consecutive drops nearly impossible. Lack of coloring may be a minor consideration, though, if the retardant is used primarily for *initial* attack on *small* fires.

Table 1.—*Characteristics of retardant dropped*

Retardant	Drop Date	No. of drops	Size of each drop	Desired mixing ratio	Density	Viscosity	Salt content: Percent DAP by weight	Salt content: Percent P_2O_5 equivalent
			Gallons		*Lbs./gal.*	*Centipoise*		
Phos-Chek 202	July 6	4	500	1.14 lbs./gal.	8.90	940	11.21	6.02
	July 10	10	1,000	1.14 lbs./gal.	8.89	920	11.08	5.96
Fire-Trol 930	July 6	4	500	5 to 1 by vol.	9.13	<50		8.69
	July 9	2	500	5 to 1 by vol.	9.12	<50		8.57
Fire-Trol 934	July 10	2	1,000	5 to 1 by vol.	9.06	<50		8.28

Summary

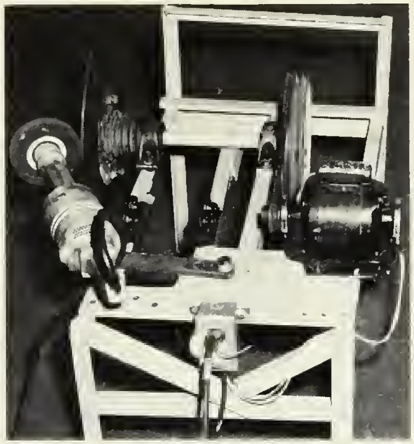
Obviously, from the limited number of drops made, definite conclusions cannot be drawn. The evaluation did indicate that unthickened liquid retardants can be successfully used in the Alaskan fuel type under difficult fire conditions and at drop heights that minimize dispersion. Success in the Alaskan situation will be greatly enhanced by development of an adequate coloring agent. Possible advantages, such as simplicity of mixing and cost of material, should also be considered. Transportation costs, logistics of summer storage, and overwinter storage of excess concentrate in Alaska's long periods of extremely low temperatures may prove to be limiting. △

FROM BACK COVER

Forward rates of spread vary with many factors from region to region. The estimated rate of spread to be used in calculation of probabilities should be developed from local studies. Most regions include rate of spread information in their Firefighting Overhead Notebook.

This table is an estimating guide only. Like other aids, its value is related to the skill with which it is used. Forward advance and shape of fire must be adjusted for actual conditions.

When placed in a source commonly carried in the field during fire season, such as the Firefighting Overhead Notebook, the table is readily available and can easily be used to reduce the margin for error in determining control requirements. △



Coulters Sharpened

Maine Forest Service

Cliff Chapman, Maine Forest Service, Unit Ranger at Gorham, has developed a device for sharpening a coulter disc.

The basic concept of this coulter disc sharpener is to mount the coulter in such fashion that it rotates and brings the emery wheel of a hand grinder into contact with the disc at the correct angle. This eliminates the danger of overheating and insures the correct bevel around the entire cutting edge of the coulter.

The Setup:

- A 1/3 h.p. motor with a 2″ pulley drives a 12″ pulley mounted on a 1 1/4″ shaft to which is attached a 3″ x 3 1/2″ pulley on the opposite end. To the 3″ x 3 1/2″ pulley is welded an 8 1/2″ x 1/8″ circular disc. Four holes are drilled in this circular disc to match the four holes in the coulter. This is the way the coulter is attached to the circular disc.
- Four additional holes are drilled in the circular disc approximately 1/2″ from the outside edge. On the side of the disc away from the coulter (when it is mounted) are welded 3/8″ nuts over these holes. 3/8″ cap screws are inserted in these nuts which are used to aline the coulter disc to insure it is rotating in a true circle.
- A 6″ Milwaukee hand grinder is mounted on a flat 2″ x 14 1/2″ x 1/2″ bar in which a hole has been drilled at each end of the bar. The handle of the grinder is removed to enable the stud that holds the handle to be used to mount the grinder on the flat bar.

The Operation:

- In positioning the grinder wheel against the coulter, the correct bevel is obtained before tightening the two bolts in the flat bar (one securing the grinder and the other securing the bar to the platform on the framework). The pressure of the grinder against the coulter is maintained by hand or by attaching a spring to the grinder. After grinding one side the coulter will have to be reversed to grind the other side.
- To convert the device to a power grindstone, the flat bar and hand grinder are removed and an 18″ grindstone set up on bearings mounted on the framework. The grindstone is turned by a belt running from the 3″ x 3 1/2″ pulley to a 10″ pulley on the grindstone shaft.
- An electrical junction box is mounted at one end under the platform. This junction has outlets to plug in the hand grinder and one for the 1/3 hp. drive motor.

For more detailed information, contact the Maine Forest Service, Augusta, Maine 04330. △

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Table Speeds Fire Spread Estimates

GARY E. CARGILL[1]

Fire perimeters can be quickly estimated using a "rate of spread/elapsed time" table. This eliminates the need for plotting the fire acreage in order to determine the perimeter of the fire, and control force requirements based on fire perimeter can be determined quicker.

Present methods of determining fire control requirements generally involve calculation of area with reference to an area perimeter table in order to find chains of fire line to be constructed. Because of the calculations involved, existing guides for estimating initial attack and reinforcement requirements are not always used as often as they might be.

Calculating the area involves plotting the perimeter and using a dot grid or map scale.

These methods, while generally more accurate for larger fires, are time consuming and require maps and hardware. When calculation of probability information is needed most during the first few hours of suppression, time, maps, and hardware are scarce. Occasionally this results in action which is too little, too late, or too much.

This article provides a table which is a quick means of figuring control requirements, because perimeter is given directly from rate of spread and elapsed time, without first calculating area or plotting the fire.

The assumption is that forward rate of spread in chains per hour multiplied by elapsed time will equal the forward advance of the fire and that the forward advance is approximately equal to the diameter of a circle which would enclose the fire area. The perimeter of the fire is then circumference of that circle with adjustments made to reflect more nearly the actual shape.

The factors involved are:
- p = perimeter
- $\pi = 3.1416$
- c = circumference
- d = diameter or forward advance of fire

The formulae are:

Minimum perimeter $= c = \pi d = 3.1416d$

Usual perimeter $= 1.5c = 1.5 (\pi d) = 4.7124d$

Maximum perimeter $= 2c = 2 (\pi d) = 6.2832d$

SEE P. 15

[1] Division of Fire Control, Southwestern Region, USDA Forest Service.

TO USE THIS TABLE

1. Determine forward ROS for fuel type and wind velocity from your Firefighting Overhead Notebook.
2. Determine elapsed time for which perimeter is desired.
3. Determine approximate shape of fire; i.e., circular, fan shaped, or rectangular.
4. On the table, locate forward ROS and elapsed time. Read perimeter from intersecting column. Use minimum perimeter for circular fires, usual perimeter for fan shaped fires, maximum for rectangular fires.
5. Acreage may be found by referring to area perimeter table.

RATE OF SPREAD (ROS) PERIMETER TABLE

Forward ROS in Chains Per Hour	Elapsed Time in Hours: 1			2			3			4		
	Chains of Perimeter											
	Min.	Usual	Max.	Min.	Usual	Max.	Min.	Usual	Max.	Min.	Usual	Max.
1	3	5	6	6	9	13	9	14	19	13	19	25
2	6	9	13	13	19	25	19	28	38	25	38	50
3	9	14	19	19	28	38	28	42	57	38	57	75
5	16	24	31	31	47	63	47	71	94	63	94	126
6	19	28	32	38	57	75	57	85	113	75	113	151
8	25	38	50	50	75	100	75	113	151	100	151	201
12	38	57	75	75	113	151	113	170	226	151	226	302
17	53	80	107	107	160	214	160	240	320	214	320	427
20	63	94	126	126	188	251	188	283	377	251	377	503
33	104	156	207	207	311	415	311	467	622	415	622	829
40	126	188	251	251	377	503	377	565	754	503	754	1005
60	188	283	377	377	565	754	565	848	1131	754	1131	1508
80	251	378	503	503	754	1005	754	1131	1508	1005	1508	2011
120	377	565	754	754	1131	1508	1131	1696	2262	1508	2262	3016

FIRE CONTROL NOTES

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FIRE CONTROL NOTES

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CONTENTS

COVER—Smoke from slash burning may contribute to air pollution. See story next page.

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Slash Burning: Pollution Can Be Reduced

JAMES L. MURPHY,
LEO J. FRITSCHEN, and
OWEN P. CRAMER[1]

Current research on the effects of slash burning on air quality is concerned with the reduction or dispersal of gaseous emissions and particulates. Guidelines for accomplishing these goals are being developed. The use of other disposal methods is also under study, particularly better utilization of logging waste.

The forest figured early in the history of air pollution, both as a cause and as a victim. Damage to forested areas by smelters was reported in Europe as early as 1884, and throughout the early Twentieth Century in British Columbia, Montana, Tennessee, and various parts of California.

In 1912, Fred Plummer, in a Forest Service Bulletin, called forest fires "the most frequent cause of widespread pollution of the atmosphere." At about this time, the Oregon State Legislature passed a law requiring burning of logging slash, hopefully trading smoke from prescribed fire for smoke and damage from wildfires.

Air Quality Act

In 1967, public concern about the polluted atmosphere resulted in the Air Quality Act, Public Law 90-148. The Engineers' Joint Council policy statement on air pollution and its control has defined air pollution as:

> the presence in the outdoor atmosphere of one or more air contaminants in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.

Attention was focused on the forestry sector, particularly in the Western United States, where fires in the forest caused smoke (cover).

Theoretically, these fires might contribute to photochemical smog such as is found in southern California. Consequently, by 1968, there were six separate research projects in the West investigating, directly or indirectly, the problem of air pollution caused by emissions from the burning of woody materials, and it looked as if the problem and need for research would soon spread to other parts of the country.

Current Research

Three universities in the Pacific Northwest, Oregon State University, Washington State University, and University of Washington, have important research efforts investigating the effects on air quality of burning in the forest. In addition, the Forest Service's Fire Laboratory in Riverside, Calif., is doing research on the air pollution problem.

Forest Burning and Air Pollution Potential

Gaseous emissions from combustion.—Some primary emissions, fumes, exhausts, smokes, vapors, may be the components of further reactions that take place in the air which may cause secondary products which may further contaminate it. In the Los Angeles basin, where natural air movement is restricted vertically by layers of very stable air and horizontally by mountain ranges, secondary products thus formed result in photochemical air pollution which may be even more objectionable than the original emissions. Such pollution is important in areas of great concentration of auto exhaust and intense sunshine; it has not yet been demonstrated whether concentrations of wood smoke under similar conditions support photo-

Figure 1.—Mechanical crushing of slash can reduce fire hazard.

[1] Respectively, research forester and associate professor, Cooperative Fire Research Project, Pacific Northwest Forest and Range Experiment Station and University of Washington, Seattle; associate professor, Forest Resources, University of Washington, Seattle; and principal meteorologist, Forest Fire Laboratory, Pacific Southwest Forest and Range Experiment Station. Stationed at Portland, Oreg.

cnemical activity.

Particulate matter.—Of the emissions from forestry burning, the particulate or visible part of the smoke is probably most important—people don't like their mountain views obscured. In comparison with other sources, prescribed burning accounts for less than 2 percent of the particulate produced by all urban/industrial and rural/agricultural sources. Forest fires are more serious, producing possibly five times the particulate from prescribed burning. So the greatest threat of smoke from the forest resulting in reduction of sunlight, visibility, and effects on various plantlife would seem still to be from wildfire.

Figure 2.—Chipping slash eliminates need for burning.

Evaluating Pollution

Intensity.—The most valid comparisons between air pollution situations must be based on concentrations and durations at locations where the pollutants may become a problem.

Different emission sources will have different effects at different times on the pollution in an airshed. Usually the greatest concentration will be at low elevation in the urban/industrial part of the airshed. Burning on forest or range land around the periphery of the airshed may, under some conditions, contribute smoke to the urban concentration.

Meteorological considerations.—For many years, fire weather meteorologists have been predicting the weather conditions that affect fuel moisture and fire behavior. The fire control specialist's decision to burn or not to burn a given slash area in the Pacific Northwest, for example, has depended on (1) a delicate balance of fuel moistures such that the slash was sufficiently dry for the fire to burn well but sufficiently damp in the surrounding forest so that spread from spot fires would not be a problem, (2) calm or light winds, (3) warm, sunny days and cool nights, (4) a prospect of rain within a few days, and (5) minimum risk of severe fire weather for at least several days following the fire. These conditions usually occur in late summer and early autumn.

Specifications for a good burning situation should also include conditions for adequate smoke dispersal. The most desirable condition is that the wind carry the smoke away from populated areas. Alternatives are that the smoke either should remain aloft, separated from the surface by a stable layer through which it cannot descend or should be greatly diluted by mixing through a deep unstable layer. The smoke dispersion advantage from mountain locations is often further aided in the Pacific Northwest by a persisting, protecting layer of cooler, heavier marine air in the valleys.

Smoke dispersal conditions are usually unfavorable at night and sometimes during the heat of the day in the valleys. So now, during slash burning season, the fire-weather forecaster may have the additional task of predicting winds aloft and stability conditions during night and day over the mountains and valleys.

Pollution Index

Oregon State University scientists have developed a preliminary potential pollution index, a daily numerical statement based on temperature differences between two levels of the lower atmosphere, as observed two or more times per day. In addition, meteorologists say that the bulk of emissions from combustion of wood either are water soluble or act as condensation nuclei. Thus burning into an active rainstorm, while often causing timing problems, would provide a convenient cleansing agent.

Management for prescribed burning.—Relying on meteorological recommendations and scientifically based indications that emissions from burning of woody materials do affect air quality, scientists and managers are cooperating to produce preliminary burning restrictions and management guidelines. These rules vary with the area and fuel involved but generally include time of year and day, weather conditions — including windspeed and direction — and fuel moisture content. Also included is the determination of restricted areas where additional smoke from forestry burning would be undesirable. Such specifications will require detailed weather predictions of atmospheric properties which are not currently predicted, such as new surface and upper air weather

conditions from the forecast areas.

Mathematical Models

A new venture like this presupposes backup by research in developing the necessary analysis and forecasting tools for the forecaster and the decision-making aids for the burning coordinator. Along these lines, scientists at Oregon State University have been developing mathematical models of smoke plumes from slash fires. The higher the smoke plume rises, the better the chance of dispersal by upper winds. Estimates are given for the rate at which fuel must be burned in order to achieve a given smoke plume rise under a known set of atmospheric conditions. "Real life" values plugged into the model suggest that the rate of heat generation, important in achieving good plume rise, is usually too small on many slash fires.

Burning and other dispersal methods.—Researchers are studying burning methods which can produce an acceptable plume rise. During the summer of 1968, scientists at the University of Washington, using an electrical ignition and fuel booster system, burned a 20-acre unit of second-growth Douglas-fir slash averaging 50 tons per acre. An estimated 37 tons per acre were consumed by the prescribed burn. The major phase of emission output was over in 1 hour and 15 minutes. The smoke plume broke through a fairly strong low-level inversion and rose to 5,000 feet where it was advected well away from the fire by upper winds.

Alternative methods of slash disposal have been developed. These include:

(1) Use of a machine-loaded *portable burner* which can burn up to 10 tons of slash per hour and costs only about $8 per hour.

(2) *Mechanical crushing* of thinning slash, which reduced hazard rating from extreme to medium at a cost of about $20 per acre (fig. 1).

(3) *Chipping slash* along roads and on more moderate slopes (fig. 2).

Timber sale contracts are concentrating on increased wood utilization also.

Conclusions

Foresters are concerned about the air pollution threat. A serious research effort is underway to determine the extent of the problem and to find solutions. Preliminary indications are that the particulate in slash smoke may be of greater importance than the gaseous components. Management of local fire behavior by fuel treatment and manipulation including sophisticated ignition techniques and fuel booster systems will provide the slash-burning manager with tools for minimizing harmful effects on air quality. Meteorological timing in management of slash burning will do much to reduce the threat of air quality impairment from burning in the forest.

Considerable emphasis is being given to disposal of logging slash by methods other than burning. Total wood utilization is improving, and this means less need for slash disposal in the future—by burning or any other method (fig. 3). And there is a growing sensitivity among foresters to the impact that drifting wood smoke may have in the next air basin—or even on the other side of the mountain. Foresters recognize the problems, and scientists and forest managers are working together to minimize the threat of impaired air quality from forest burning. △

Figure 3.—Greater utilization will reduce the amount of slash and debris left in the forest, a basic solution to the problem of air pollution. Instead of adding to slash fuels, these small hemlock logs are headed for the pulpmill via Crown Zellerbach's Utilizer II chipper. (Crown Zellerbach photo.)

Timelag Useful In Fire Danger Rating

JAMES W. LANCASTER[1]

The timelag principle, applied to natural fuels, has proved to be very useful in fire danger rating. Timelag provides a satisfactory key to fuels classification. Use of an established relationship between actual drying conditions and standard laboratory drying allows evaluation of moisture trends in natural fuels. Field applications are feasible.

Men concerned with wildland fire control have classified fuels for many years. Until quite recently, these classes were fairly general and usually based on physical factors. Adjectives such as flash, fine, light, medium, and heavy have been used as descriptive fuel terms. Fuels are a major factor in the behavior of all fires. Davis (*2*) has included three chapters that are basically concerned with fuels and fire behavior. This book should be included in every fire control reference library.

During recent development of the National Fire Danger Rating System, researchers have investigated the drying rates of various natural fuels. Fuel responses to drying conditions can furnish a means of grouping them into classes. Timelag, a measure of drying rates, provides the key to the classification problem.

Timelag

A more definitive method for considering fuels was stimulated by general acceptance of the timelag principle, proposed by fire physicist George M. Byram.[2] Current practice in fire research and in danger rating has been to use this principle to systematically evaluate moisture responses. Its use has simplified the problem of working with fuels in a wide range of sizes and forest floor depths.

Timelag is an expression of the rate at which a given fuel approaches its equilibrium moisture content, a condition wherein a fuel is very close to being in equilibrium with the moisture content of the air immediately surrounding it. At this stage, no further significant net exchange of mositure will take place. Actually, in nature this is a transitory situation, since the atmospheric conditions surrounding the fuel seldom remain stable for long. The concept, however, is valid and very useful. Byram's concept defined a timelag interval, or response time, as the time required for dead fuel to lose approximately 63 percent of the difference between its initial moisture content and equilibrium moisture content. Usually timelag is expressed in minutes or hours; days have also been used. For clarity, hours are preferred.

For research investigations and comparison purposes, researchers established standard drying conditions of temperature and relative humidity. These have been generally accepted as a relative humidity of 20 percent at a temperature of 80°F., and, depending upon pressure, a dew point of about 56°F. Through laboratory evaluation of moisture responses to standard values, fuels may be compared and conveniently grouped into timelag classes.

Fuel Classes by Timelag

Fuels with very small diameters should respond quickly to changes in the surrounding atmospheric moisture. These fuels are said to have a short timelag. Exposed mosses, lichens, and cured grass have timelags of less than one hour. The uppermost layer of dead, weathered conifer needles in the forest floor probably has a timelag of less than 2 hours. Dead twigs, up to about ¼-inch diameter, will generally respond within 2 hours.

The next logical breakpoint in grouping fuels by timelag falls at about 20 hours.[3] Fuels whose timelags range from 2 to 20 hours occur in a shallow litter-duff layer of the forest floor and also include twigs and branchwood from about the ¼-inch to 1-inch diameter class.

Moving up the time scale, the 20- to 200-hour class consists of a deeper portion of the litter-duff fuels and cylindrical fuels in the 1-inch to 3-inch size range. Larger wood, logs, and very deep duff or organic material constitute the 200-hour plus timelag group.

There is always some uncertainty in specifying exact timelags of fuels. Timelags may vary in natural fuels of the same size but of differing species or condition. Timelag variations in wood can often be tied to structural differences in fiber cavities and pit systems (*6*). Even within a given species, timelags may differ due to surface weathering, rot, locality, exposure, and other conditions. Heartwood and sapwood differ in wood from the same source (*5*). Surface coatings or impregnations of waxes, resins, and other materials also influence timelag (*8*).

Logical Dead Fuel Classes For Fire Danger Rating

Some research has identified timelag ranges for specific fuels —much more is needed. The

[1] Forester, RM Forest & Range Exp. Sta., USDA Forest Service, Ft. Collins, Colo.

[2] Byram, George M. 1963. An analysis of the drying process in forest fuel material. Paper presented at the 1963 Int. Symp. Humidity and Moisture, Washington, D.C., May 20-23. 38 p. (unpublished)

[3] Fosberg, Michael A., Mark J. Schroeder and James W. Lancaster. Classification of dead forest fuels by moisture timelag. (Manuscript in preparation for J. Forest.)

timelag concept can be very useful, however, even though values have not yet been identified in most field situations. By means of timelag classes, proper weighting may be assigned each fuel portion in a heterogeneous natural fuel bed to assist in fire behavior interpretations.

Spread and energy release components for danger rating may be calculated and values assigned to certain timelag classes. These values can be entered into fire danger indexes according to the appropriate fundamental relationships. The physical laws that govern fire behavior mechanisms may thus be fully considered, and the resulting danger rating system will be sound. As fire research provides additional answers, they may be similarly fitted into the structure of the danger rating system.

Fuels with a timelag of 2 hours or less will respond sharply to the normal daily fluctuations of atmospheric moisture. These fuels can best be represented by using the midpoint of their range and classifying them as 1-hour timelag fuels. Such fuels have also been referred to as the *fine fuel* regime (*7*).

Fuels around the 20-hour timelag show much less response to daily changes in atmospheric moisture content. It is therefore reasonable to use this characteristic to define another breakpoint in a logical fuel grouping system. Fuels in the range of 2 to 20 hours can thus be represented by the midpoint of 10 hours. The 10-hour timelag class may then be termed the *light fuel* regime.

Beyond the 20-hour-class fuels are the deeper duff materials, included in the larger branchwood and stems of the 100-hour or *medium fuel* class. These fuels show very little response to daily moisture cycles, but a definite response to moisture changes over the recognized 30-day cycle. Their midpoint was set at 100 hours.

The next fuel regime, including large logs and very deep duff or organic soils, may require several to many months to dry out. Fuels in this category may be placed in the 1000-hour timelag, or *heavy fuel* class. Heavy fuels respond to extreme drying or drought conditions and to annual fluctuations in the weather.

Because fire control people frequently use the adjectives fine, light, medium, and heavy to describe fuel-size regimes, these terms are proposed for application to the 1-, 10-, 100-, and 1000-hour timelag classes, respectively. The timelag descriptors are preferred but may require some years to gain wide acceptance.

Standard and Field Drying

The preceding concepts help to form the basis and background for a fire danger rating answer to the familiar and important question: "How dry are the fuels?" For a fire manager to get a feel for the timelag principle, however, he needs some basis to relate local field drying conditions to standard defined drying conditions. He will want to know how dead fuel drying in his area today or last week or so far this season might compare to the standard. The National Fire Danger Rating Project recently completed a study that provides the bridge between laboratory and field drying conditions (*4*).

In laboratory experiments, fuels are often first exposed to specified temperature and humidity values until they reach equilibrium. In our study, we examined the related theories and used mathematical techniques to relate standard to field conditions. We demonstrated that the relationship between the average moisture content of a dead fuel on any given drying day and that of the same fuel under

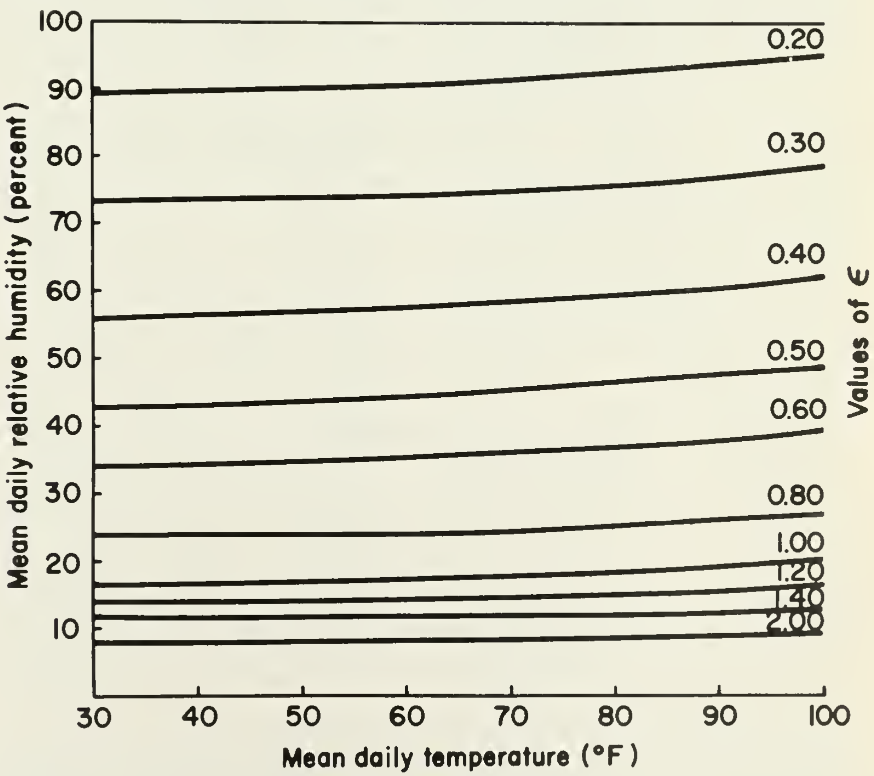

Figure 1.—Graph to obtain epsilon (ε), the relationship between standard and field drying of forest fuels.

standard drying conditions is predictable. This relationship, expressed as a ratio, may be used to evaluate moisture changes in natural fuel beds.

Figure 1 presents this relationship.[4] The resulting ratio, or epsilon (ε) from the graph may then be compared to the standard. A ratio of one means that the drying conditions equaled standard and this was defined as a standard drying day; less than one indicates that drying was less than under standard conditions. A ratio of more than one means that more than standard drying has taken place.

Three or four timelag periods are usually required in nature before most fully saturated (200% M.C.) dead fuels reach the flammable stage, (about 30% moisture content). An additional graph (fig. 2), may then be used to obtain the moisture content at the end of subsequent timelag periods. The beginning moisture content of the fuel must be known, as it is used as one entry to the graph. The other entry is the epsilon value, derived from figure 1. Repeated entry to this graph will enable the user to follow a fuel moisture trend through consecutive timelag periods.

Under standard drying conditions, the following example traces a fuel drying from fiber saturation, about 30 percent moisture content:

Timelag Period	*From*	*To*
1st	30%	14%
2nd	14%	8%
3rd	8%	6%
4th	6%	5%
5th	5%	4½%

If standard conditions are maintained, the minimum moisture content reached will be about 4½ percent. This represents an epsilon value of 1. The minimum moisture content that can be reached at given epsilon values are shown below as M_e.

ε	M_e (%)	ε	M_e (%)
0.15	30.0	0.8	5.6
.2	23.0	.9	5.0
.3	15.0	1.0	4.5
.4	11.0	1.2	3.8
.5	9.0	1.4	3.2
.5	9.0	1.6	2.8
.6	7.5	1.8	2.5
.7	6.4	2.0	2.3

It should be emphasized that drying in most places is usually less than standard. A rule of thumb to follow would be that the epsilon value in a dry climate usually ranges from 0.6 to 0.8; in a humid climate, the values will usually be within the 0.2 to 0.5 range. For any given day, of course, epsilon values may be con-

See TIMELAG, p. 10.

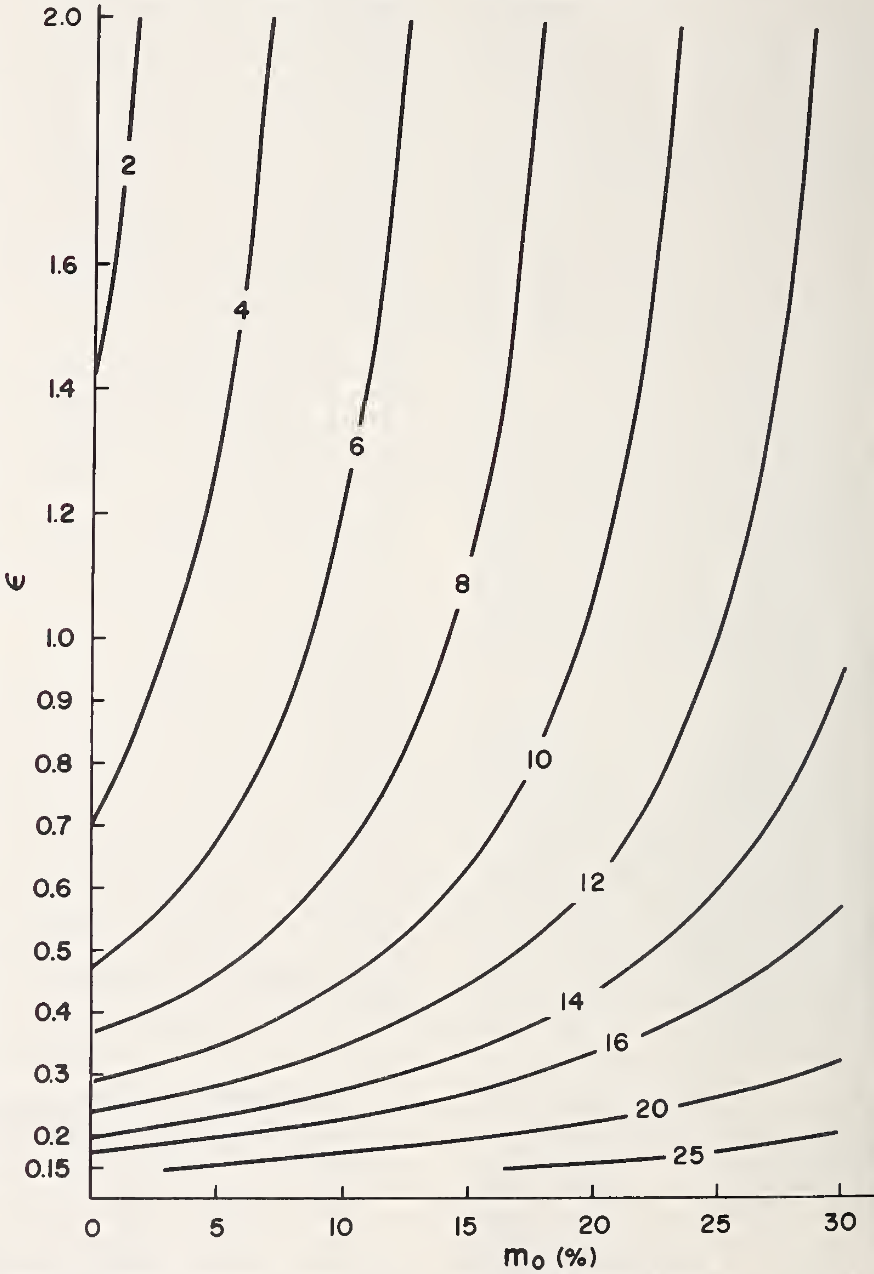

Figure 2.—Graph of moisture content of fuels at the end of a timelag period. m_0 = beginning moisture content; ε = drying relationship obtained from fig. 1. Read moisture content result from curves.

[4] Entries are the averages of daily temperature and relative humidity. Usable averages may be computed by adding the maximums and minimums for the day and dividing by two.

THE QUEBEC JOINDER
Quebec Becomes A Member Of Forest Fire Protection Compact[1]

A. E. ECKES[2]

The Province of Quebec has joined the Northeastern Interstate Forest Fire Protection Compact. Other members of the Compact are Maine, New Hampshire, Vermont, New York, Rhode Island, Connecticut, and Massachusetts.

The annals of forest fire control must record September 23, 1969, as a great, not black, day. All too often, the historical records of forest fire control emphasize the big burns but fail to include significant developments leading to the prevention of fire disasters. Beginning with the Peshtigo Fire of October, 1871, in Wisconsin and continuing through the Sundance Fire of September 1967 in Idaho, there is a long list of fire disasters.

Without smoke, flame, or heat, September 3, 1969, has become a significant date in the world of forest fire control: The Province of Quebec became a full-fledged member of the Northeastern Interstate Forest Fire Protection Compact.

Back when . . .

Throughout the northeastern States and eastern Canada, October 1947 was dry, hot, and dark. A summer drought became an autumn nightmare. In Maine, three major fires — Alfred, Brownfield, and Bar Harbour — burned more than 250,000 acres. Numerous lesser fires burned in the New England States, New York, and Canada. Property losses ran high: homes burned, numerous small industries and businesses wiped out, family possessions lost, and villages and schools destroyed. After the fires, there was a realization that no single State could afford to employ and equip a forest fire organization adequate to cope with such a holocaust.

A Governors' conference, followed by studies by representatives of interested agencies, led to a decision to employ the Interstate Compact device to provide the suppression forces and facilities which would be required should another catastrophic fire situation occur. The 81st Congress enacted Public Law 129 granting consent and approval of Congress to an interstate forest fire protection compact. "Be it enacted by the Senate and House of Representatives of the United States of America in Congress Assembled, that the consent and approval of Congress is hereby given to an interstate forest fire protection compact, as hereinafter set out; but before any province of the Dominion of Canada shall be made party to such compact, the further consent of Congress shall be first obtained." In 1952, the 82nd Congress enacted legislation which gave consent and approval for joinder of the Canadian Provinces.

A First

These Acts made it possible to establish the first interstate compact for prevention and control of forest fires. The six New England States and New York, along with any State or Canadian Province contiguous to a member State, were specified in the law as eligible for membership. Six states enacted necessary legislation in 1949 and the Northeastern Forest Fire Protection Compact became effective. The legislature of Rhode Island met in 1950 and approved a measure that enabled compact membership.

For 20 years, 1949-1969, membership in the Northeastern Forest Fire Protection Compact remained at seven States. The Canadian Provinces of Quebec and

[1] This article is used with permission from *American Forests* in which it appeared April, 1970.

[2] Forester, Northeastern Area, State & Private Forestry, USDA Forest Service.

New Brunswick indicated interest in membership but encountered obstacles which prohibited an early joinder. But representatives of the forest agencies of these provinces kept working to remove the obstacles. Persistence paid off, and by mid-1969, it was quite clear the Province of Quebec would soon be ready for joinder. September 23, 1969, was the day Quebec was to become a full partner in the Northeastern Forest Fire Protection Compact.

The Ceremony

Invitations were sent out to selected forest fire control people in the United States and Canada to participate at the ceremony in the Legislative Council Chamber and in the presence of the Prime Minister of Quebec, the Honourable Jean-Jacques Bertrand.

The agreement was signed by the Honorable Claude G. Gosselin, Minister of Lands and Forests, representing the Province of Quebec, and Austin H. Wilkins, Forest Commissioner, Maine Forest Service, who is current Chairman of the Northeastern Forest Fire Protection Commission. The Province of Quebec is now a member of the first forest protection compact, and the compact has become an international fire control agency. △

Figure 1.—Ceremony marking the Joinder of Quebec to the Northeastern Forest Fire Protection Compact—September 23, 1969. (Government of Quebec photo.)

TIMELAG, from p. 8.

siderably outside these ranges.

Although standard drying days are not frequently encountered in nature, epsilon values were near 1.0 in 1967, during the large fires (Sundance, Trapper Peak, and others) in the Pacific Northwest. Low humidities and high temperatures close to standard drying were recorded then at many high elevation stations (*3*). Unusually warm, dry nights are often the tipoff that drying conditions are severe.

The days following very warm nights have been identified by Bates as troublemakers in the Southwest (*1*). Since relative humidity is dependent upon temperature, it follows that most such nights also have low humidities. In this situation, fuels with short timelags probably do not partially recharge with moisture at night as they usually do. Many experienced fire people have been aware of this relationship and have used it to advantage in fire control activities.

Conclusions

An understanding of the timelag principle is essential to knowledgeable use of fire danger rating. Certainly in the future, much more use will be made of this concept in fire control work.

Fire managers and others who wish to follow or investigate moisture trends in natural fuel beds now have an additional tool available: the established relationship between laboratory and field drying conditions.

The relationship may be used to evaluate the moisture change of a specific fuel during a time period. It may also be used to compare the time required for a fuel to reach a specified moisture content, under field conditions, with the time required under standard drying conditions. A fuel regime of known moisture content may be followed through several timelag periods to establish its flammability at any point in time.

Fuel classes based on timelag will continue to be a major aid to systematic fuel appraisals. A fundamentally sound fire danger rating system, tied to timelag, should serve fire control purposes well for many years.

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Fire Potential Increased By Weed Killers

CAPTAIN O. L. FORMAN[1]
D. W. LONGACRE[2]

A spray solution of sodium chlorate and metaborate applied to grass and weeds increases their ignitibility in comparison to the same ingredients applied in pellet *form.*

The occurrence of 22 fires along a divider stretch on a freeway in Los Angeles prompted Los Angeles City Fire Department officials to be suspicious of a weed killer used by the Road Department. Tests conducted on this brand of weed killer by the Los Angeles City Fire Department determined that the application of the weed killer did abruptly change the ignition characteristics of grass and weeds.

This report is the result of tests of brands of weed killers consisting of the same basic ingredients in common use by road departments, utilities, and governmental agencies.

It was found that the application of weed killer *sprays* with basic ingredients of sodium chlorate and metaborate to standing grass and weeds abruptly changes the ignition characteristics of grass and weeds to the point that they should be considered highly flammable. Grass and weeds treated with these chemicals can be instantly ignited by cigarettes, and the fire spreads rapidly.

Details of Tests

On April 18, 1969, two separate 10-foot square plots were chosen for the test site. The plots were located near San Dimas Canyon in Southern California on lands of the Los Angeles County Nursery. Ground cover in the plots and surrounding area consisted of assorted annual grasses and weeds typical of Southern California.

Plot #1 was used to test a product with a brand name of Chlorea which came in a pellet form. The chemical composition was 57 percent sodium metaborate, 40 percent sodium chlorate, one percent fenuran, 2 percent inert. This weed killer is commonly used under bridges and other areas where moisture is available. Although it can be mixed with water and applied as a spray, it is commonly broadcast by hand. For purposes of this test, it was broadcast by hand (fig. 1). After broadcasting, it was sprayed by means of a water hose.

Plot #2 was sprayed with a solution of the weed killer by the brand name of Chlorax "40" and water as directed on the package. The chemical composition of this product is 40 percent sodium chlorate, 58 percent sodium metaborate, 2 percent inert.

Inspection

By April 23, 1969, 4 days after treatment, the plots were inspected. Plot #2, the one sprayed with the solution, was already burning brown, but little effect was apparent on Plot #1. On April 29, 1969, Plot #2 had dead weeds lying over, but Plot #1 was just turning brown.

Finally, on May 12, 1969, with the temperature at 73 degrees and a humidity of 62 percent, a lighted cigarette was applied to both plots. The fuel moisture was quite high, and, by scraping a finger along the grass stems, drops of moisture could be squeezed out. The cigarette in Plot #1 simply smoldered until it finally burned out. Immediately upon contact with the fine fuels, the cigarette in Plot #2 started a fast-moving, smoldering type fire accompanied by a hissing sound, similar to the sound made by a burning fuse. Since this fire never broke into an open flame, the investigators finally had to extinguish the burning material to save the plot. Cigarettes were also placed in the grass and weeds outside of the plots during this test but they simply went out.

On July 10, 1969, accompanied by an Engine Company and patrol pumper from the Los Angeles County Fire Department, the investigators again went to the test site. The temperature was 92 degrees, and the humidity was 29 percent. Many lighted cigarettes were laid, buried, and thrown into the dry grass and weeds surrounding the treated plots, but none started a fire. All were allowed to burn out completely, taking approximately 16 minutes for each cigarette.

A lighted cigarette was then placed into the fine fuel in Plot #1. A small smoldering fire final-

Figure 1.—Applying pellet weed killer to Plot #1.

[1] Fire investigator, Los Angeles County Fire Department.
[2] Special agent, USDA Forest Service.

ly resulted but only burned a spot before going out.

Ignition

A lighted cigarette was then placed in the fine fuel in Plot #2, the one which had been treated

Figure 2.—Fire spread 6 seconds after cigarette was placed in plot treated with spray weed killer.

with the spray solution. Instantly a fire stated and in 6 seconds the fire was well established and spreading rapidly (fig. 2). The Engine Company had to act quickly to save the plot from being entirely consumed. Further tests in this same plot produced exactly the same results. Veteran firemen witnessing the test were appalled at the rapidity of ignition and spread.

Recommendations

Due to the abrupt increase in ignition characteristics of fuels treated with this type of weed killer, *spray* application along roadsides, trails, and utility pole areas and around camp ground structures should be judiciously practiced. △

Can Airport Weather Stations Compute Fire Danger Spread Index Ratings?

Richard A. Mitchem and Charles A. Pigg[2]

A comparison was made of the fire danger spread index computed from forest fire danger stations with that computed from airport weather installations to determine if one of these data sources is superior to the other. This comparison was made for each of four unit areas covering parts of Alabama and Mississippi for the time period of February, March, and April, 1966. While exact conclusions are precluded by insufficient data, airport weather installations appear to be an acceptable source of basic information for computing fire danger ratings.

The Object

The object of this study was to compare fire danger ratings made at forest-fire danger stations with those compiled from observations made at standard airport weather installations, and to determine if one of these sources is superior to the other in representing actual fire activity. If forest burning potential is adequately reflected in information gathered daily at airport weather installations, foresters may find it advantageous to incorporate this data source into fire danger measurement planning.

The study area consisted of four unit areas, each with an air-

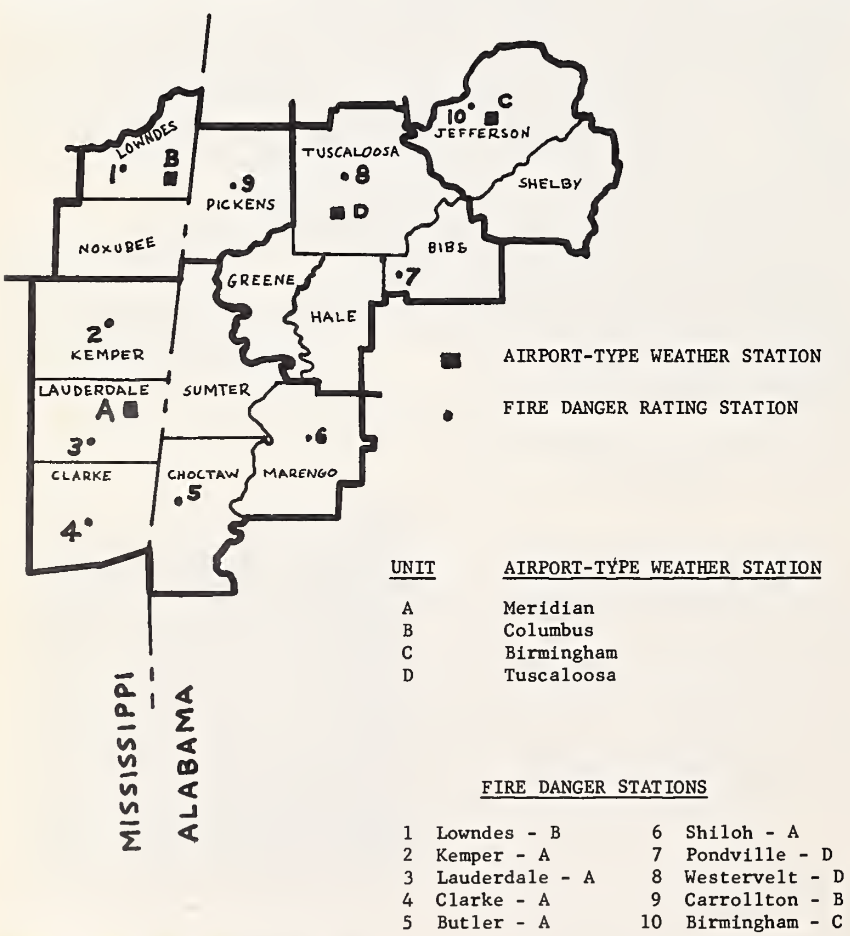


Figure 1.—Fire Danger Rating Study Area.

[1] Respectively, forestry meteorologist, U.S. Weather Bureau and assistant chief fire control, Alabama Forestry Commission, Montgomery, Ala.

port weather installation and one or more standard fire danger stations. Figure 1 depicts the study area and acreage information. The spread indexes were determined by the National Forest Fire Danger Rating System. The 1:00 p.m. data was used at all stations. The spread indexes at the airports were compiled from the 1:00 p.m. weather observations with the exception of 24-hour precipitation that is routinely reported at noon.

The period of time was 89 consecutive days, February 1 through April, 1966. This period of time during the year was chosen since fire activity is usually the greatest and a wide range of burning conditions exist. The data was based on a relatively small population sample. The spread index range was narrow and seldom reached the higher ranges.

Basic Assumption

A basic assumption was made that, ideally, fire activity will increase progressively as fire danger increases. A curve depicting fire activity compared to spread index could take one of a wide variety of shapes, theoretically, but no reversals should occur in its slope. The slope of the curve would be expected to reflect increasing values of fire activity to increasing value of spread index in every instance. Because of the limited data used in this study, other factors not related to recognized elements of fire danger may have distorting effects on fire activity. These factors may include, among others, detection and suppression capability and varying fire risks. The assumption is further made that the effects of these variables do not invalidate, although they may distort, the relationship between fire activity and the fire danger rating.

Procedure

For each unit, the fire danger each day was rated, using two sources of fire danger data: the spread index from fire danger stations and the spread index from airport weather installations.

In order to consider all the fire-danger stations in a unit, a weighted average spread index was determined. The weighting was based on the area served by each danger station in each unit.

In order to facilitate handling of data, the spread indexes were grouped into the following categories: 1-2, 3-5, 6-10, 11-15, 16-20, 21-30, 31-40 and greater than or equal to 41 ($\geqq$41).

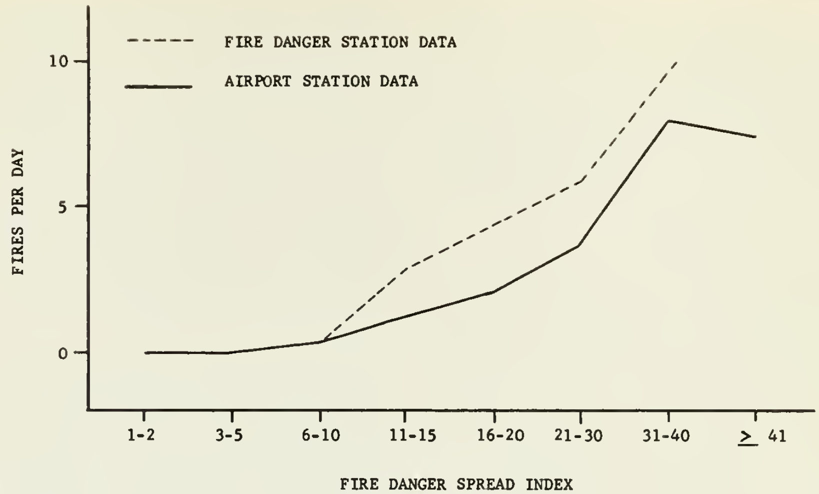


Figure 2.—Comparison of ratings based on forest fire danger station data to ratings based on airport station data, Unit A.

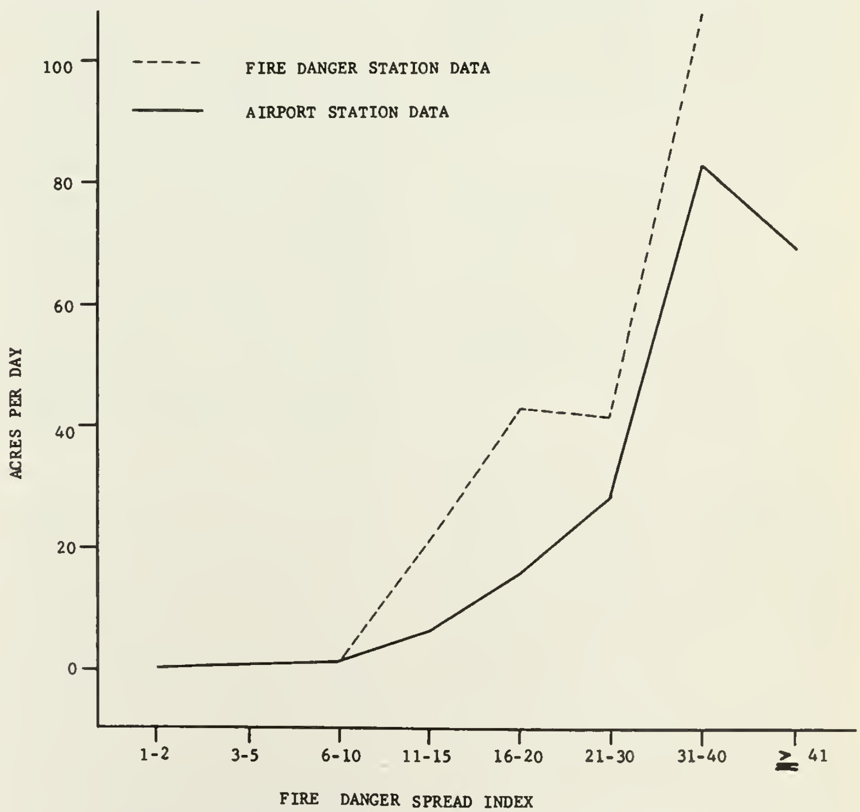


Figure 3.—Comparison of ratings based on forest fire danger station data to ratings based on airport station data, Unit A.

The number of wildfire starts reported and the area burned each calendar day was determined for each of the four study units. Then for each fire danger data source, this information was tabulated for each Spread Index Category.

From these tabulations, average number of fires per day and average acres burned per day were computed for each Spread Index Category. For brevity, typical results for the study units are characterized by figures 2 and 3, which depict the actual values for Unit A. Specific descriptions and values for the units are available from the author on request.

Results

With some deviations, all four units show essentially the same results: in the great majority of cases, ratings based on forest fire danger stations depict higher fire activity per spread index category than ratings based on airport data.

Difference in wind speeds for airport stations and forest fire danger stations are thought to be the reason for the differing curves. Wind speed is an important factor in spread index—the higher the wind speed, the greater the spread index.

Wind speeds at airport weather installations are generally greater than at forest fire danger stations. This would make the spread index for any particular day usually higher for ratings based on airport data than for ratings based on forest fire danger data. Consequently for most days the spread index based on airport data would be thrown into a higher category than that based on forest fire danger stations.

Thus, for airport data ratings the spread index categories of 16-20, 21-30, and 31-40 would collect a number of days when only a small amount of fire activity occurred. This being the case, spread indexes for these categories would show less fire activity on the average for airport based data than for forest fire danger based data.

Additionally, because of greater wind speeds at airport-weather installations, ratings based on this data would have more days which fall in Spread Index Category of ≧41. Airport based data had spread indexes in the category in all four units, while forest fire danger based data had spread indexes in this category in only one unit.

Short Range Data

Due to the rather short range of data, the authors hesitate to state definite conclusions. In general, the danger rating curves based on airport data follow a more theoretically logical form than that based on forest fire danger stations. Additionally, the airport data curve is smoother and shows fewer reversals. The airport based data curve does show a reversal in some units at Spread Index Category ≧41. This dip may result from public awareness and therefore guardian action on critically hazardous days.

Even though the airport data curves indicate greater smoothness and theoretical applicability, the forest fire danger data curves seem to be more valid when the spread index ranges used to define Class of Day are applied; i.e., Class Four days are usually bad burning days, which is quite clearly depicted in the forest fire data curve but not in the airport data curve. △

Portable Calibrator Developed For Anemometers

Paul W. Ryan[1]

Establishment of anemometer turning-rate curves can be easily accomplished by using the portable instrument described. Through use of centrifugal blowers, the calibrator generates discrete turning forces which are calibrated in terms of true laminar windspeed. The calibrator was built to accommodate Stewart anemometers but can be used with any anemometer of that size or smaller, or it can be enlarged for larger types. Parts to duplicate the instruments should cost approximately $50.

Calibration of anemometers used in fire-danger stations must be performed routinely if accurate windspeed readings are to be maintained. Periodic recali-

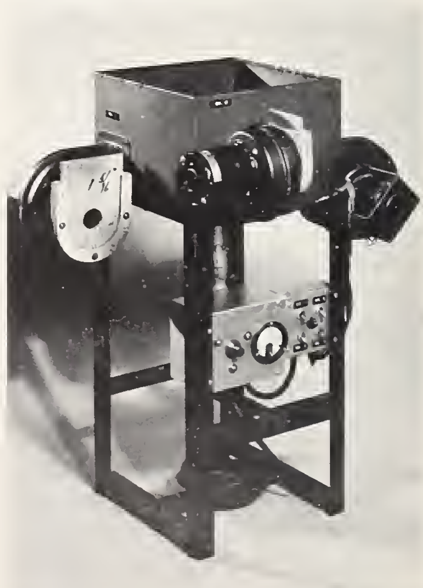


Figure 1.—The portable calibrator: air restriction devices mounted over the fan inlets control the rotational force applied to the anemometer cups.

[1] Fire systems analyst, Southeastern Forest Experiment Station, Southern Forest Fire Laboratory, Macon, Ga.

brations are not done by many organizations simply because they do not have access to an adequate calibration system. Wind tunnels which generate closely controlled, accurately known windspeeds are ideal for anemometer calibration but are not generally available.

Portable Calibrator

A portable calibrator for anemometers (fig. 1) has been developed which may be used when other, more sophisticated systems are unavailable. It does not rely on true windspeed, but employs what can be called a "calibrated turning force." This instrument has been used in Georgia since early 1966 when a pilot program of periodic anemometer recalibration was instituted. The anemometers in 36 of Georgia's fire-danger stations have been marked for identification and every year are overhauled, including stripping and cleaning, replacement of parts as necessary, lubrication, reassembly, and recalibration with the portable instrument.

Advantages

This process takes less than 1 hour per anemometer and has resulted in substantial improvement in the accuracy of windspeed readings taken at these fire-danger stations. The first checks on some of the anemometers, for example, revealed calibration errors as high as 28 percent. The maximum change in calibration detected in subsequent yearly checks has been about 5 percent, with an average for all anemometers running around 2 percent. Portable calibrators similar to the ones used in Georgia would be helpful to other organizations in maintaining their anemometers.

Construction

The portable calibrator was built to accommodate Stewart anemometers. The calibration chamber is a Bud box (type Cu881) and measures 12x11x8 inches. This is supported by a framework of $1\frac{1}{2}$-inch angle iron. Detailed construction plans are not presented since the size of the calibrator would be altered for other anemometer types. Little trouble should be encountered in duplicating the unit or in building a similar one after examining figures 1, 2, and 3.

The "turning force" of the calibrator is provided by four motor-driven centrifugal fans mounted so the airstream emanating from them crosses the path of the rotating cups tangentially. The anemometer is aligned and held in position by means of a bushing in the center of the chamber bottom and a pipe support clamped at the base of the unit. Care should be used so that anemometer cups are always in the correct position, i.e., directly in line with the airstreams

Versatility

The inlet from each fan is fitted with a wooden frame which accepts any one of several air restrictors. Various combinations of energized motors and air restrictors can be selected to cover the range of the instrument. For example, our calibrator develops a turning force equivalent to a true wind of 8.8 m.p.h. when motor number one is energized, and it has a restrictor with a $1\frac{5}{16}$-inch hole in place. All other motors are deenergized with solid restrictors in place. The highest speed generated by the calibrator is 23 m.p.h.

The four fan motors are parallel wired and have individual switches so that any combination may be activated at one time. Voltage to the motors is controlled by a variac and monitored by a meter. Line voltage should be set at the same level each time the calibrator is used.

Cost

New parts to duplicate this calibrator should cost approximately $50. The blowers represent the largest single cost; they are 60 c.f.m. units, available for about $7.50 each.

After the calibrator is constructed, the "turning forces" generated by various combinations of energized motors and air inlet restrictors are calibrated with the aid of a "standard" anemometer. This standard must be one of the general class to be calibrated and must have known turning rates for given true windspeeds. Preferably the standard anemometer's turning rate characteristics should be accurately determined in a wind tunnel. If this is not possible, the standard could be a new anemometer with no defects. A new anemometer will probably follow, within a given tolerance, the general calibration curve established for its type by the manufacturer. Lower calibration accuracy may result if this alternative is followed. Once the standard anemometer has been selected it should only be used for maintaining a check on the accuracy of the portable calibrator.

The Design Theory

The design theory behind the rotational characteristics of anemometers is based on the assumption that the cups will be turning in laminar airflow. This type of airflow is created in the test sections of well-designed wind tunnels and is found in natural wind fields when there are no turbulence-producing obstructions. This calibrator does not produce a laminar windflow; however, the "turning force" it generates can be calibrated in terms of true laminar windspeed. Instruments calibrated in the unit will therefore read true windspeed under operating conditions. △

Mobile Communications Centers Tested

DIVISION OF FIRE CONTROL[1]

Large fires require extensive and complicated communication. A self-contained, mobile communications center has been suggested as one way of meeting this need.

A number of these vehicles are already in use by police, fire departments, civil defense agencies, and others. Several were investigated by the Beltsville Electronic Center to determine their suitability for use on large fires. The following ten categories were used to evaluate the mobile centers:

1. Acoustics within vehicle.
2. Ventilation, air conditioning, and lighting in operator's area.
3. Readiness of communication equipment for use:
   (a) Radio (including all nets used on fires).
   (b) Telephone.
   (c) Public address system.
4. Mobile antennae.
5. Masts for raising antennae.
6. Provisions for extending controls to another operating center.
7. Adequate space to operate base consoles.
8. Self-contained power source.
9. Flexibility of movement—either under its own power or towed.
10. Fixtures and equipment permanently mounted to protect against damage in transit.

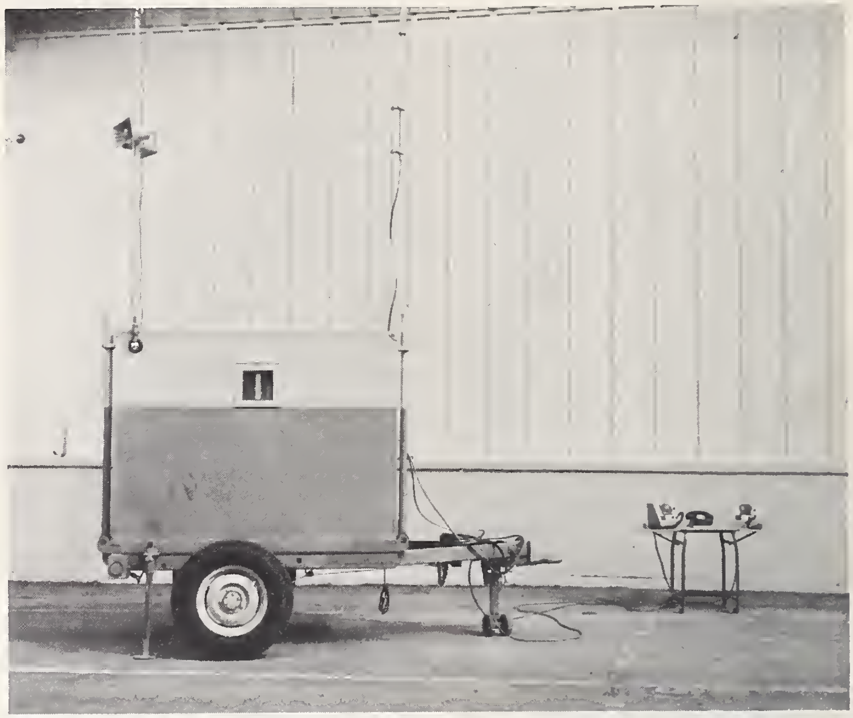


Figure 2.—Top view: the anemometer cups inside the test chamber rotate in response to the airstreams produced by the blowers.

Large Buses Used . . .

Large buses, vans, and trailers are often used as communication centers. The mobile center designed by Kenneth P. Green, electronics technician on the Mendocino National Forest appeared to meet best the requirements of the Forest Service in California. The Beltsville Electronics Center, Bldg. 419 ARC, Beltsville, Md., can provide more information on this mobile unit.

Fire communication needs will determine the most effective type of mobile center for each individual agency. Equipment criteria will vary according to the agencies' protection responsibility and wildfire load. △

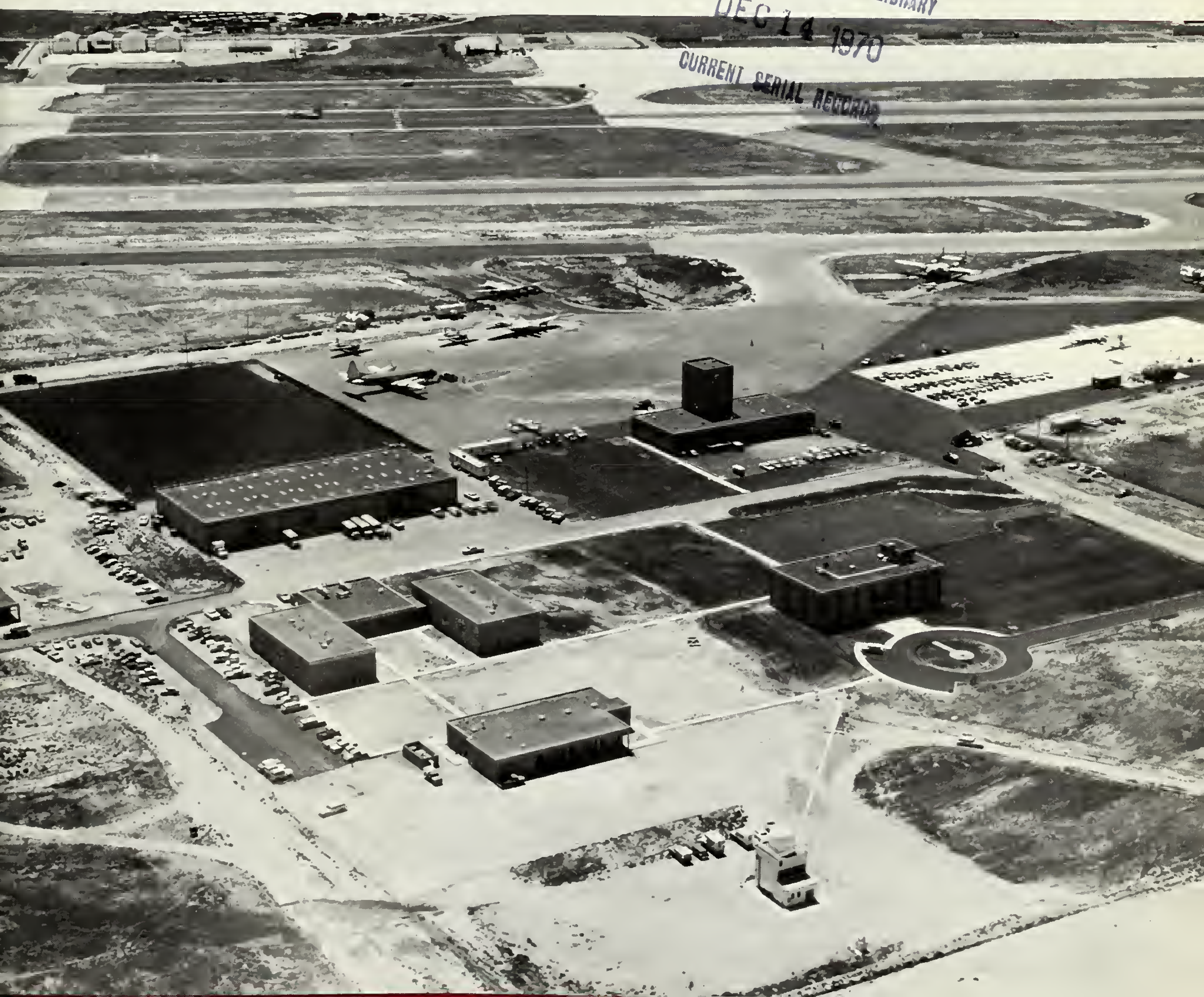
[1] USDA Forest Service, Washington, D.C.

FIRE CONTROL NOTES

FALL 1970 • VOL. 31, NO. 4

U.S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE

Boise Interagency Fire Center



FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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(NOTE—The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such does not constitute an official endorsement or approval of any product or service by the U.S. Department of Agriculture to the exclusion of others which may be suitable.)

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Three Agencies Tighten Fire Control

Dedication Ceremony Officially Opens Fire Center

The July 25th dedication of the Boise Interagency Fire Center marked the virtual completion of the unique triagency facility. The Bureau of Land Management, USDA Forest Service, and ESSA Weather Bureau operate the Center, which has a mission to more effectively control forest and range wildfires in the Western United States and Alaska.

Dedication Activities

At the ceremony, local residents were entertained by the Idaho National Guard band from Caldwell prior to the 10:00 a.m. flag raising. Governor Don Samuelson and Mayor Jay Amyx officially welcomed those attending. Following the ceremony, an informal "open house" was held.

Visitors toured the weather instrument area, the training building, the crew building, the warehouse, and the smoke-jumper loft. They also saw on-base aircraft and the air tanker base. Exhibits and displays were located along the tour route.

Construction of a hangar-avionics shop complex and a physical conditioning area for smokejumpers and suppression crews is planned for a later phase of construction.

Three Chiefs Speak

Paying tribute to the joint operation, agency chiefs from Washington, D.C. spoke. Edward P. Cliff, chief, Forest Service; Dr. George P. Cressman, director, ESSA Weather Bureau; and Boyd L. Rasmussen, director, Bureau of Land Management agreed that opportunities for the three agencies to work together effectively are greatly enhanced when men, equipment, and a modern airport facility are brought together.

The speeches, which outlined each agency's part at the Center, are excerpted below.

Edward P. Cliff, chief, USDA Forest Service:

The Boise Interagency Fire Center brings into reality a need, long recognized by Federal, State, and local fire control agencies. The Center will facilitate early action on the forest and range fires that occur in the Intermountain area. We were pleased to join with the Bureau of Land Management in the development of a joint center that will serve the needs of both agencies and through its joint nature provide strength through unity. We are also pleased that the Weather Bureau could join with the land management agencies in this cooperative venture. The Weather Bureau, by making Boise its "hub of fire weather activities" in the West, will greatly strengthen the decision-making process by fire control personnel at the Center.

The Forest Service has other fire centers throughout its western Regions, where smokejumpers, aerial tankers, firefighting supplies, and transport aircraft are centralized for sharing by several National Forests. This new Center at Boise will serve the Forest Service chiefly in its Intermountain Region, comprising Utah, Nevada, southern Idaho, and western Wyoming. Smokejumpers and aerial tankers from this Center will take initial action within a radius of approximately 150 miles of Boise. Tools and equipment will be dispatched as back-up for larger fires in the entire Region. The Center, however, will not be expected to supply all of the equipment for the largest fires or for all large fires in the Region, since the various fire centers of the Forest Service provide backup for one another. This flexibility among Regions gives us strength. Now, by combining forces with the Bureau of Land Management at Boise, our fire support capability not only in the Intermountain Re-

Fire fighters dispatched through BIFC.

Firefighters are fed in the new mess hall-barracks building prior to leaving for fire fighting duty in Alaska.

gion but throughout the West will be further strengthened.

Site Selection

Boise was selected as the site for this Interagency Fire Center because it is centrally situated to vast areas of Federal lands in the Western United States that experience high fire occurrence and therefore require intensive fire protection. Most of these lands are isolated by poor access, thus requiring effective aerial attack and support operations to help keep fire losses within tolerable limits.

The same favorable locations led to the selection of this Center not only as a base for initial attack on adjacent National Forests, but also as a Forest Service base of operations for some key national fire support units.

Specialized Forest Service Facilities at the Center

The Forest Service infrared mapper unit is based here. This highly sophisticated unit has been operational since 1966 and has been used to map numerous large wildfires throughout the Western United States and in Alaska for the Forest Service and Bureau of Land Management. Intelligence thus obtained has provided current information to fire managers and is making an important contribution to effective resource protection.

The Forest Service national radio cache is also based at BIFC, where radio units can be quickly dispatched to fire problem areas throughout the western Regions. These radio units are used to provide effective communications to fire managers on large fires and are available to the Bureau of Land Management and other cooperators.

Several Forest Service interregional aircraft are based at the Center, where they are used to transport men and supplies to fires. Future plans call for construction of an aircraft hangar at the Center so that our aircraft can be maintained and repaired to keep them operational during critical periods.

This is the newest and one of the best fire centers in the nation. We believe that through interagency training and fire cooperation with the Bureau of Land Management and with close support by the Weather Bureau we can do a better job of protecting our valuable forest and range resources from fire at less cost to the taxpayer.

George P. Cressman, director of the Weather Bureau:

The Weather Bureau is pleased to participate in this Boise Interagency Fire Center venture. Here our fire weather specialists are in "eye-to-eye contact" with Forest Service and Bureau of Land Management fire dispatchers. Here we have an ideal arrangement to enable meterologists to bring expected "weather influences on fire" directly into the decision-making process with respect to control of forest and range fires.

Fire Weather Meterorology is a specialization that has advanced very significantly during the past 10 years, and particularly so in the West. In the area west of the Great Plains, the Weather Bureau has 24 offices from which we provide fire weather service to the control agencies. Forecasts from all of these offices are received here at BIFC. Here the information is consolidated, condensed, por-

Snake River Valley Crews load their gear aboard the Electra prior to boarding the plane for the State of Washington to fight forest fires.

trayed, and displayed for use by the fire dispatchers.

Center is a Hub

With the development of Boise Interagency Fire Center, the Weather Bureau has made Boise its "hub of fire weather activities" in the West. Our Western Fire Weather Coordinator is located here. We expect to do development work in fire weather operations at Boise Interagency Fire Center. We expect to train our Western Region fire weather meteorologists here by periodic detail. And we expect our fire weather program throughout the West to be strengthened by virtue of practices developed here and transplanted to the other fire weather offices in the West.

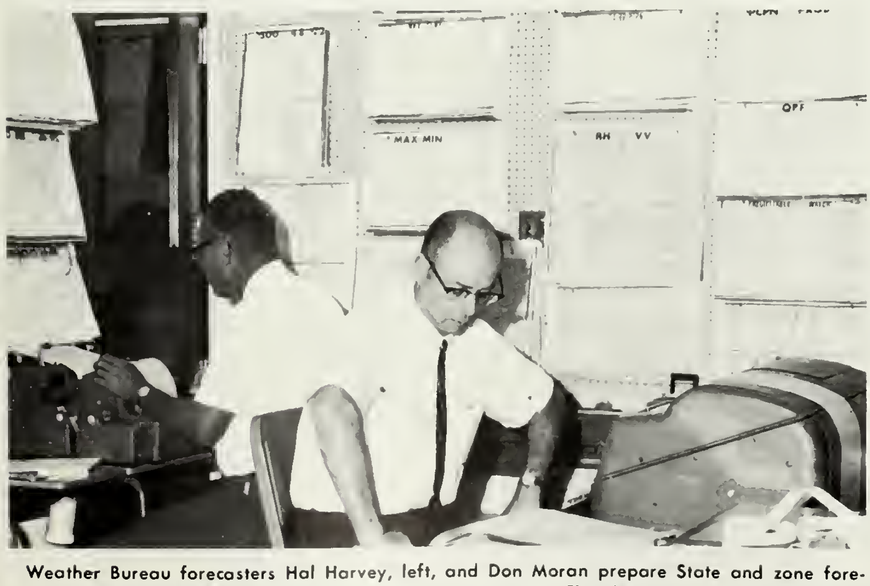
The Weather Bureau's physical plant at BIFC is one of the finest in the Nation. Its communications facilities bring the very latest of weather information to Boise from throughout the northern hemisphere. By means of facsimile, the latest computerized current and prognostic weather charts are received directly from Suitland, Md., the home of the National Meteorological Center. By radar and facsimile the office here will receive hourly maps showing the location and areal extent of thunderstorm activity throughout the West. And, of course, the office has facilities and instrumentation for a complete weather observational program, including balloon soundings twice daily to measure temperature, air moisture, pressure, and wind direction as well as speed from the ground surface upward well into the stratosphere.

Boyd L. Rasmussen, director, of Bureau of Land Management:

The Boise Interagency Fire Center reflects the modern organizational trend towards centralization and specialization; it is a positive effort to hold the line on fire control costs in the face of rising prices for all goods and services. It is in the public interest that two fire control agencies and a mutual support agency — each from a different department of government — have pooled their resources for greater economy and effectiveness.

For the Bureau of Land Management this is indeed a happy day. It marks the culmination of 5 years' effort to develop a national center for support of the Bureau's fire control activities— which cover some 400 million acres of public domain lands throughout the Western States and Alaska.

Boise Interagency Fire Center. The BLM dispatch office is nerve center of activity for dispatching manpower, equipment, and supplies to any fires on request.



Weather Bureau forecasters Hal Harvey, left, and Don Moran prepare State and zone forecasts in the Weather Bureau offices at the Boise Interagency Fire Center.

BLM Centers

BIFC is a logistical support center for the Bureau of Land Management as well as for other Department of the Interior agencies with fire control responsibilities in the West—the National Park Service, the Bureau of Indian Affairs, and the Bureau of Sport Fisheries and Wildlife.

At BIFC the Bureau of Land Management also has its national fire coordination center. It develops standard basic training programs for use in all field offices and offers advanced courses for instruction. Training in firefighting techniques, in the use of specialized equipment, and in all phases of fire management is given. The Bureau's aircraft operations in the Western States are centered here, and its warehouse can equip 5,000 men.

The centralized fire support dispatch office for BLM and other Interior agencies in the Western States and Alaska is in this building. All support services are channeled through it. The data gathered here daily from each State on going fires, relative fire danger, manpower availability, as well as current and predicted weather conditions, enable BIFC to better manage and coordinate BLM's firefighting resources during all emergencies.

The agencies who have developed this Center look upon wildfire as a national emergency—not any one agency's emergency. Thus, we have combined our forces to develop the Boise Interagency Fire Center and have defined its purpose as that of achieving—in the national interest—more effective control of forest and range wildfires. △

Elite Teams Fight Fires

W. J. Vogel [1]

Editor's note: Mr. Vogel presents here his ideas for solving a common problem. Articles describing other possible approaches to maintaining available trained and competent fire overhead would be welcome.

Each year we receive more inquiries and questions from our forestry personnel regarding details to large fires. The newer employees want experience; the more experienced want to maintain their levels of experience and qualification ratings and remain abreast of new fire control techniques. However, each year it becomes more apparent that if Federal forest fire protection agencies are going to maintain even a small nucleus of project fire-experienced personnel, they are going to have to limit fire details to a *select few.* Furthermore, adequate large-fire experience for even these men can be achieved only by detailing these individuals freely between Federal fire protection agencies.

Lots of People, Little Experience

We must all admit that the ideal condition of forestry personnel receiving large-fire experience or on-the-job fire training has become impossible and impractical — at least for any positions higher than a sector boss. There are three main reasons for this: (1) there just aren't enough large fires to "go around," even in high fire-occurrence years, (2) forestry staffs have been greatly expanded and (3) the higher fire-command positions have become specialized. The high value of timber and other resources, the use of advanced technical methods and specialized equipment, and the high cost of suppression have made it impossible for every staff member to receive the amount of training he needs.

By attempting to spread experience-training details to more than a small, select group, we are defeating our purpose—no one receives an adequate amount. The fire qualification standards require a great amount of large-fire experience, but this amount of experience is almost impossible to get. Efforts should be concentrated toward providing most of this experience for a select few, with the other staff personnel obtaining their experience locally, on smaller fires.

We wouldn't send members of our staffs out to make an accurate prism cruise or administer a large timber sale or survey a primary logging road location once every 3 to 5 years—and expect acceptable results. Therefore, why do we expect an efficient performance from upper-level fire overhead who do not have sufficient training and experience? It isn't good business for a fire organization and it isn't fair to the individuals when inexperienced personnel are assigned to fill responsible fire-line positions.

Fire Trainee Program Inefficient

Our so-called "fire trainee" programs also need to be examined. With the conditions encountered and many demanding duties facing overhead personnel on large fires today, there either isn't time or it isn't taken to use trainees in a project fire organization. I have yet to be on a large fire where men were assigned and *functioning* in a "trainee" status as intended. Yet each year we establish lengthy rosters and make promises to ourselves and newer employees to detail men to fires as "trainees."

The "fire trainee" programs, impressive on paper and theoretically sound, have continued to fill training manuals and fire plans, which is as far as they have proven practical.

The only workable and financially sound program is one of *progressive training and experience for the few* who have the aptitude, potential ability, and desire, and who will *remain* in fire control during their entire career. It is of little benefit to the individuals or agencies to move personnel from fire control duties just when they are

[1] Fire control officer, Yakima Indian Reservation.

becoming experienced enough to fill a higher level fire-command position.

With the concept of training a few men in firefighting, the major portion of large-fire upper-level command positions would be filled by people who would be experienced, confident, and able to perform their duties adequately and efficiently. Also, with only a small group trained for these positions, they would serve together more often, which would lead to a smoother functioning fire command. Finally, administration of an intensive program of this kind would be much easier and more efficient.

Elite Teams

It seems to me 10 or 12 elite overhead teams should staff any Federal project fire in the Nation. These teams would consist of the best fire control personnel from each Federal forest fire agency and any Federal agency with a developing project fire would call for a team from an inter-agency dispatcher. The teams would be dispatched on a rotating basis.

Seldom do Federal agencies experience 10 or 12 project fires at any one time, but to guard against the possibility, there could be several supplemental teams which would be used only in such extreme cases. With elite teams servicing all Federal project fires, the suppression efficiency and money saved would soon prove the worth of the system.

What's Holding Us Up?

There is a unique attitude which prevails towards fire control that is not found in any other phase of Federal forestry. The majority of forestry personnel consider themselves proficient fire overhead. If you are inclined to disbelieve this, pause and try to remember the last time you heard a fellow forestry employee or administrator admit he knew little about fighting fires. Even Smokey Bear's image and campaign perpetuate the idea that forestry personnel are *all* seasoned firefighters.

This might have been true early in the history of Federal forestry when the major portion of time was devoted to fire control and the largest problem encountered was getting the number of men with shovels that were needed. As a result of this attitude, it seems to be disgraceful to ask for fire overhead if one's jurisdiction doesn't have someone capable. To go outside of the parent organization for more capable overhead is practically unheard of.

Yet, when problems are encountered in other phases of forestry, we don't hesitate to ask for the help of specialists from any available source. Possibly it's because of tradition or the so-called glamor and excitement which may be connected with fire fighting, but whatever the reasons for this attitude, it impedes rather than strengthens the progress of efficient fire control.

This same attitude has been the stumbling block to the establishment of *inter-agency teams* of fire experts. Unless we change, this attitude will continue to block a more efficient method of providing overhead fire teams. It is time we accept the idea that everyone in forestry is *not* proficient in fire control. It is time administrators admit they and their staffs aren't all fire control experts. It is time administrators accept trained fire overhead teams as they accept help in the other phases of forestry. Once we all realize fire control is a very complex and specialized phase of forestry, the establishment of expert, inter-agency fire overhead teams will follow shortly.

The Federal forest fire organizations should meet together now and begin laying the groundwork for the establishment of this more efficient method of staffing project fires. △

Fire Control Notes Offers Its Services

This article[1] began the first issue of *Fire Control Notes*, December, 1936. Though the words were spoken by the Fire Control Division Chief 34 years ago, they are still true. *Fire Control Notes* is YOUR magazine; support it with your knowledge and ideas.

Roy Headley

The Fire Control Meeting at Spokane, Wash., in February, 1936, gave the Forest Service Division of Fire Control in Washington, D.C., a mandate to issue from time to time a publication which would serve as a medium for exchange of information and ideas between all the groups and individuals who are doing creative work in forest fire control. On the assumption that readers will respond with ideas and information to publish, the mandate is accepted.

Over a period of 30 years since the inception of organized effort to stop the fire waste of American natural resources, impressive advances have been

[1] This article is reprinted in part.

made. A considerable body of knowledge of the arts and sciences involved has accumulated. Systems of organizing and managing human forces and mechanical aids have in some instances attained dramatic efficiency. Fire research has won the respect of owners and managers of wildland. The advancement to date in technique entitles fire control to a place among the amazing technologies which have grown up in recent decades.

Technology Advancing

The advance of the technology of forest fire control is not, however, a completed thing. Its forward march has not even begun to slow down. On the contrary, there is good reason to anticipate a period of broader and more rapid growth. Fire control has won a large measure of public interest. Its relation to conservation of wildland resources is better understood. Financial support is increasing. A growing number of men are making technical contributions from a wider range of ability and training. More men know more about how to climb to new plateaus of efficiency in stopping this fire waste.

Future advances will come not from the work of small groups, but from the experience, thinking, and experiments of the large number of men now engaged in pushing back the frontiers of fire control. The integrated experience and study of such a body of interested men may easily yield results overshadowing all that has been gained so far.

Advances Now Published

Fire Control Notes will seek to act as a channel through which useful or suggestive information may flow to each man in this field, whether he be a fire research worker attacking some fundamental of combustion, or a firefighter facing the flame and smoke, who discovers some new device for organizing a crew of laborers. These pages will also hope to be used as a mouthpiece for every man, whatever his job, who discovers something which would be useful to others, or who has a criticism to make, a question to raise, or an unusual fire experience to relate.

As implied by the name, *Fire Control Notes,* it matters not how long or how short a contribution may be nor what angle of fire control is presented. The man who discovers some new device which can be presented in four lines owes it to himself and others to report it. Likewise, the fire research man who needs ten pages for a worthwhile presentation of his subject should share what he has learned with others who need his help or who may be needed to supply the intelligent interest required to sustain the inquiry.

The Only Requirement:

The only requirement imposed upon contributions to *Fire Control Notes* is that they be interesting or helpful to some group of people concerned with some phase of fire control.

Distribution will not be limited to members of the Forest Service, but will include all who are cooperating with it in stopping forest fire waste. Copies will be sent to State forest organizations, cooperative protection associations, forest schools, Federal bureaus interested in fire control, and Canadian and other foreign organizations dealing with fire problems. Within reasonable limits, any individual who is not included in the organizations mentioned may be placed upon the mailing list by agreeing to constitute himself or herself a committee of one to discuss with friends the need for habits of care in the use of fire. △

COMMENTS INVITED

Charles E. (Chuck) Syverson, right, Fire Weather Meteorologist at Boise Interagency Fire Center provides on-the-spot weather information to District Ranger Bill Paller near the fire camp. Fire Control managers base their suppression action on expected fire behavior which is influenced by weather factors.

In this issue of *Fire Control Notes* are three articles about interagency cooperation: Dedication Ceremony Officially Opens Fire Center, p. 3; Elite Teams Fight Fires, p. 6; and Teletype Maps Display Predicted Burning Index Using Overlay, p. 12.

Your comments on any of these articles or on anything you read in *Fire Control Notes* is invited. Address letters to *Fire Control Notes*, Editorial Branch, FS I&E, RP-E 1001, U.S. Department of Agriculture, Washington, D.C. 20250. △

Prescribed Nighttime Burns Bring Benefits[1]

STEPHEN S. SACKETT AND DALE D. WADE[2]

A nighttime prescribed fire successfully reduced the wildfire hazard created by slash left in a recently thinned plantation of 20-year-old slash pines. Weather, fuels, and fire behavior are briefly described.

Prescribed burning, if properly applied, is the most economical means of eliminating the wildfire hazard created by slash left in pine plantations after a commercial thinning. One such burn designed to reduce slash, although originally scheduled for the daytime, was successfully carried out at night on the Southlands Experiment Forest, International Paper Company, near Bainbridge, Ga. If these prescribed burns can be conducted at night, the number of hours available for burning are increased. The project was part of a cooperative study by the Southern and Southeastern Forest Experiment Stations.

The area was a 20-year-old plantation of slash pine *(Pinus Elliottii Engelm.)* to which prescribed fire had previously been applied in the fall of 1966 and in the spring of 1967. These fires had reduced the litter on the area from 16 to 4 tons per acre. In December 1967, the plantation was thinned to one-half its original density; approximately 200 8-inch trees were removed per acre. Total ground fuel was increased to 10 tons per acre by the resulting slash (fig. 1).

The time scheduled for this prescribed burn was the day light hours of March 19, 1968, based on predicted weather conditions. By that afternoon, however, the air temperature had risen to 82° F., and the windspeed was 4 m.p.h. The relative humidity had dropped to 21 percent, creating a relatively low, fine-fuel moisture of about 8 percent. According to the nearest Fire Danger Rating Station 7 miles away, the buildup index (a measure of cumulative moisture deficiency in fuels beneath the surface layer) was 28 and the spread index (a measure of the relative rate of forward movement of surface fires) was 20. These indexes indicated a high fire-danger condition. Burn-

Figure 1.—Total fuel after thinning was approximately 10 tons per acre.

[1] Reprinted with permission from *Forest Farmer* 29(5): 11, 18 February 1970. (Official Publication of the Forest Farmers Association)

[2] The authors are associate fire behavior scientists of the Southeastern Forest Experiment Station, USDA Forest Service, Southern Forest Fire Laboratory, Macon, Ga.

ing under this combination of fuel moisture and weather would probably damage crop trees.

By 9:00 that evening, conditions were more favorable for burning: the air temperature had dropped to 63° F., and the relative humidity had risen to 66 percent. As a result of this increase in relative humidity, fuel moisture had risen to 14 percent. The windspeed recorded 4 feet above ground level in the plantation was 1 to 2 m.p.h.—enough to give direction to the fire and dissipate some of its convective heat. Because of this improvement in conditions, a decision was made to go ahead with the burn.

Fire Begun

The relatively light winds dictated the use of a head fire (fire set to spread with the wind) for slash reduction. A backfire was used to widen the downwind control line by reducing the fuel along its inner edge. The head fire progressed at a rate of 265 to 345 feet per hour. Flames varied in height from 2 feet in the litter to 5 to 8 feet in heavy concentrations of slash, and higher flames were occasionally observed. Some glowing embers landed outside the control lines; but, because of the high humidity and increased fuel moisture, no spot fires developed.

All slash less than 0.5 inch in diameter was consumed. Litter was reduced by 74 percent, leaving 1 ton per acre and virtually eliminating any threat from wildfire (fig. 2). Crowns were scorched on 12 percent of the trees, but less than 2 percent of the trees died. Most of those killed were suppressed trees too small to cut during the thinning operation. Greater windspeeds would probably have prevented crown scorch and shortened burnout time without aggravating the problems of control.

These results demonstrate the suitability of prescribed burning at night as a management tool for the prevention of wildfire hazards. Not only did the decision to burn at night increase the time available for burning, but it also provided an additional means of regulating the prescribed fire's intensity. △

Figure 2.—Fine fuels were virtually eliminated by the prescribed fire.

Excess-Flow Check Valves Prevent Propane Accidents

LAWRENCE L. DOWNEY[1]

Portable pressurized propane tanks equipped with a torch are used extensively for a variety of burning projects. These burners are carried by hand or mounted on a packboard so that the operator can use both hands.

A pressure regulator is attached to the propane container by a POL (pressure overload) connector. The body of the regulator contains a pressure gauge mounted near the outlet side of the regulator. The purpose of the gauge is to provide the operator with a visual reading of the pressure being applied to the torch. The torch assembly is mounted at the outlet side of the regulator.

Fire!

In November 1969, a regulator failed while a burner was being used on a project. Mounted on a packboard, the burner was being carried by the operator. He had ignited one slash pile and was turning to walk to the next. As he turned, he heard gas escaping. The escaping gas was quickly ignited by the burning slash. The operator dropped the packboard and burner to the ground and ran a safe distance away. Flames kept the operator from shutting off the main valve on the can. The uncontrolled, escaping propane burned for about 40 minutes.

Later examination revealed that a failure had occurred in the regulator at the stem of the pressure gauge.

Review Conducted

A fault-finding review of the entire assembly indicated two locations subject to stress and possible failure. The first is the connection between the propane container and the regulator. The second is the pressure gauge stem. It is recommended that the POL connector used to attach the regulator to the propane container be equipped with an integral excess flow check valve. The check valve will automatically shut off the flow of gas in the event of a break between the container and the regulator. It is further recommended that the pressure gauge be removed and the hole plugged. Most operators adjust the regulator pressure to produce the amount of flame they want. They use the pressure indicator very little. Removal of the pressure indicator eliminates the most likely area of failure in the regulator.

The Answer

Incorporation of a POL connector with an integral excess flow check valve and removal of the pressure gauge from the regulators will minimize the likelihood of a mishap while using the propane burners. △

[1] Forester, Bass Lake District, Sierra National Forest.

MASS FIRE PHENOMENON IN SUNDANCE FIRE

Researchers have conducted an intensive study of the Sundance Fire which occurred in northern Idaho in 1967. Five features of a mass fire system were identified: (1) simultaneous ignitions caused by flying firebrands, (2) high energy output, (3) strong fire-induced winds, (4) violent firewhirls and erratic wind behavior, and (5) strong vortex action downstream from the burning area. Calculations showed a high probability that firebrands traveled more than 12 miles. fire intensity reached 470 million b.t.u./sec., and induced winds exceeded 80 miles per hour. The conditions necessary for a mass fire in a coniferous forest include continuous fine fuels, sustaining drying conditions, relative humidity less than 30 percent, and ambient winds greater than 20 m.p.h. △

FIRE REPORTS SYSTEM

It is only through a uniform system of fire reporting that a dependable body of facts bearing on the fire protection problem can be developed. . . . It is through such a system that we can obtain the data necessary for a knowledgeable and economic attack on the problem. . . .

By using a uniform code, it will be possible to pinpoint the trouble areas and hazards, and then concentrate our efforts in those areas and hazards.

. . . from the Introduction to *Coding System for Fire Reporting* (NFPA No. 901) National Fire Protection Association. △

Teletype Maps Display Predicted Burning Index Using Overlay

Robert E. Lynott and Howard E. Graham[1]

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AREAL DISTRIBUTION OF PREDICTED BI  USE WITH TRANSPARENT OVERLAY.
      ISSUED 1550 PDT 08-05-70 VERIFY 1400 PDT 08-06-70.
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                  03             10        33  38.
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    0C                  06        11    31.
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                    04  04  27.
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              9024  24  37              40        25        27     20.
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  07                          30.
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      //                               35                25     26.
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10                 23.
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 11              26    34  31          36         35                 48.
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1210          29     29                        26.
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19.
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   31                29        40            41        26.
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      27.
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Figure 1.—Teletype page data printed after being automatically sorted by district. The four-digit numbers represent districts too small to be printed on the overlay. They should be read as follows: 9024—The BI for District 90 is 24. // means no data were available.

A new display of predicted Burning Indexes is part of the 1970 advances in the program for improving fire danger data management in the Pacific Northwest Region of the Forest Service.

Beginning in late summer 1969, predicted BIs for designated areas, called weather zones, were computed centrally at the Forest Service Regional Office by Automatic Data Pro-

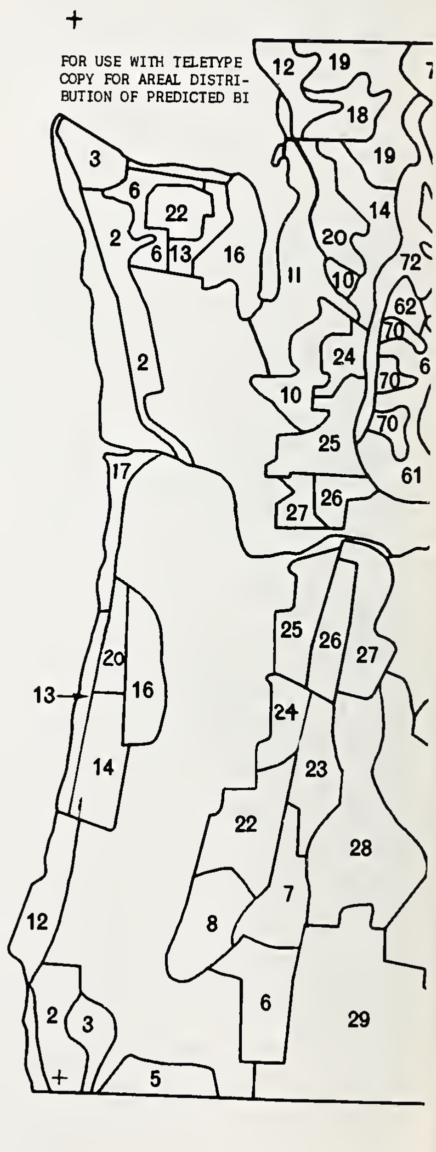

Figure 2.—Part of map overlay of districts.

cessing (ADP). The values then were distributed by teletype to the nineteen National Forests. The tabulation was simply a numerical listing like the example below:

322 - 32	463 - 29
323 - 38	464 - 27
324 - 26	470 - 28

The figure on the left of each column was the zone. The figure on the right of each column was the Burning Index (BI).

Unless the data were plotted on a map, it was difficult to visualize the areal distribution of predicted values.

Automation now does that map plotting on the teletype. The computer calculates the predicted BI for each zone from weather values provided by the fire-weather forecaster. Each BI value is automatically sorted to its proper position on a grid and transferred to the teletype.

In each Supervisor's and Cooperator's Office, the data alone on the teletype page seem to have been arranged at random as shown in figure 1. They are meaningless until a transparent map overlay showing districts (fig. 2) is placed over the page. Presto (fig. 3)! The areal distribution of values is clearly displayed.

The predicted BIs for weather zones are visible for comparison. Such easy comparison is important for several reasons. First, the forest supervisor can quickly inspect the data for continuity. There should always be continuity in values from zone to zone. That is, the transition in predicted values should be consistent with differences in terrain and expected weather patterns. Second, other cooperating forest protection agencies, including the Weather Bureau, have access to this teletype map and interagency coordination is facilitated. Third, offices with overall responsibility, such as the Regional Office, can quickly locate trouble spots.

The days of enforced "tunnel vision" are no more. Each forest can watch what is happening to its neighbors, as well as to itself.

△

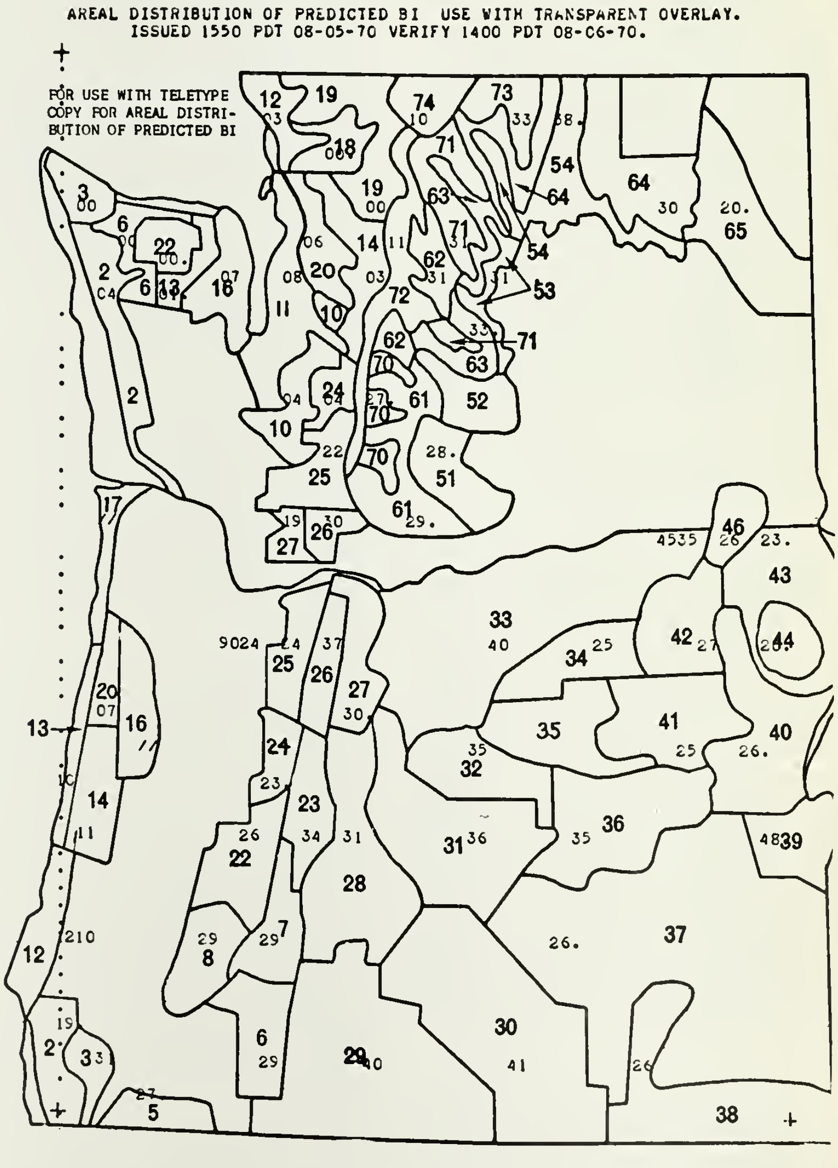

Figure 3.—Map overlay in place on teletype sheet. BI for each district is clearly indicated.

[1] Meteorologists, Division of Fire Control, USDA Forest Service, Portland, Ore.

Testing Service Rates Wetting Agents

R. W. JOHANSEN AND J. E. DEEMING[1]

Wetting agents used in forest fire control are evaluated for wetting ability.

A comparative testing service has been instituted at the Southern Forest Fire Laboratory, Macon, Ga., for those interested in using wetting agents in their forest fire control activity. This service was initiated at the request of National Forest Systems to enable District Rangers throughout the country to determine if they were using effective products—at reasonable concentrations and reasonable costs.

Parameters Determined

Before the testing program began, it was decided that worthwhile comparisons of products could be made by evaluating the following parameters: (1) solubility in water, (2) solubility in phosphate solutions, (3) foamability, (4) foam breakdown rate, (5) surface tension, and (6) wetting action (Skein Test, ASTM D2281-64T). The manufacturers were asked to supply data on cost, corrosion, and toxicity. Verifying corrosion tests are planned on the more promising wetting agents and will be conducted at the Equipment Development Center at San Dimas using a system established for corrosion tests of fire retardants. While selecting these parameters, it was also decided that only liquid concentrates (as opposed to powders and pastes) would be considered because of the ease with which they can be handled.

The perfect wetting agent was visualized as a liquid concentrate that would give good wetting action at less than 1 percent concentration. The solution should also be nontoxic, noncorrosive, highly soluble, and low foaming. The foam that does appear should break down rapidly.

As of January 1, 1970, we had tested 74 products. These included some new products, as well as some that were being used by fire control agencies throughout the United States. They were all tested for effectiveness in both water and a solution of 15-percent diammonium phosphate and water. The phosphate solution was used because of considerable local interest in using the low-viscosity phosphate retardant together with a wetting agent for mopping up after fires in heavy duff or an organic soil.

Which Ones Passed?

Those agents that meet minimum wetting standards are entered on a list of products "Approved for USDA Forest Service Use." Every chemical is rated for each of the test parameters mentioned. Also included is an estimated cost of chemicals per 1,000 gallons of solution at our recommended minimum concentration. Thus, an economic comparison of all rated products can be made. A subscriber to the list can then make an easy decision as to what product will be used in his operation.

We noted that, for a number of products, the manufacturers' recommended concentration failed to meet our minimum wetting standards. Those minimum concentrations recommended in the list approved for Forest Service use are believed to be realistic.

The list of "approved" wetting agents can be obtained by sending inquiries to:

Division of Fire Control
Forest Service, U.S.
Department of Agriculture,
South Building, 12th &
Independence Avenue, SW.,
Washington, D.C. 2 20250

Or:

Southern Forest Fire
Laboratory,
Southeastern Forest
Experiment Station,
Post Office Box 185,
Macon, Ga. 2 31202

Test Procedures Available

Anyone interested in knowing what test procedures were used to measure the rated parameters can send inquiries to the authors at the Southern Forest Fire Laboratory.

[1] Fire systems analyst and associate fire control scientist, respectively, Southeastern Forest Experiment Station, Southern Forest Fire Laboratory, Macon, Ga.

TRACKER, from back page.

large number of people were living. Although the District Ranger came to no conclusion as to which one, if indeed any, of the occupants was responsible for causing the fire, there were no further outbreaks.

Tracked Suspects Flee

On May 25th, the dogmaster received a request to patrol an area in Hants County where several fires of incendiary origin had occurred earlier in the month. During the patrol, a fire started in woodland about one-half mile from the road. Taken to the fire's perimeter, the dog followed a track to another small fire and then to a house. Then he led the dogmaster to a second house, behind which two men were seated. The arrival of the dog and ranger surprised them, and the following day both men left for Central Canada. Fire troubles in that area ended for the season.

By mid-June, Rommel proved to have certain characteristics which limited his usefulness as a tracking dog for the Department. It was decided not to purchase him, and, consequently, he was returned to his owners in July.

Major

Encouraged by the results of the trial use of a tracking dog to curb incendiary fires, a male German Shepherd pup was purchased for training to the Department's specific requirements. "Major" was placed centrally in the province with the same ranger who had handled Rommel, and training was begun.

The 1967 fire season was wet. Fewer than half the normal number of fires occurred, and no situation developed meriting the use of a tracking dog.

During the 1968 season, Major was used six times for fire control assignments. None resulted in convictions. Yet, it was apparent that his use was a deterrent to incendiaries. On one occasion, a teenaged boy was tracked from a point near a fire perimeter through swamps and heavy brush to a house a mile away.

Game Law Enforcement

During the late summer and fall of 1968, Major was used on no less than 15 occasions for game law enforcement. He was also involved in investigating a fatal hunting accident. He located seal beam lights, ammunition, hunting knives, rifles, and deer carcasses for use as evidence in court. He also successfully tracked game law violators through wooded areas at night. The courts accepted him as being "well trained and qualified for the purpose used."

Expanded Program

Before the spring of 1969, fire control planners decided to acquire two additional pups for training for use in the western and eastern regions of the Province. Until this time, Major had been handled part-time by a District Ranger. Now, three full-time dogmasters were appointed. In June, a fourteen-week training course began using a training manual written by the original dogmaster, who now became Chief Dogmaster.

In mid-July, Major took time out from the course to assist in apprehending a man suspected of setting a five-acre fire in slash. The man was consequently convicted under Part II of the Lands and Forests Act.

Sabre, one of the junior German Shepherds, distinguished himself in late September by finding a toddler lost in a wooded area of eastern Nova Scotia.

The Decade Ahead

All three tracking dogs have been successfully transported in float-equipped Beaver aircraft. Because they are too large to carry inside a Bell G2, a "flying doghouse" has been constructed. It mounts on one of the floats of the helicopter, and will be tried in 1970. Hopefully, this innovation will make it possible quickly to transport both dog and dogmaster to the fire's perimeter. The incendiary will have to move with speed.

As we enter a new decade, our hopes are that we have found an effective way of reducing, to a minimum, fires of incendiary origin. One thing is certain. They can no longer be set with impunity. △

Fire Weather Handbook Is Available

Fire Weather, Agriculture Handbook #360, has been published. Years in the making, it was coauthored by Charles C. Buck of the Forest Service and Mark J. Schroeder of the Weather Bureau. Culminating 45 years of fire research and fire weather forecasting experience. It is expected to become a classic reference and working tool for forest managers. Public and private foresters, rural fire departments, weather forecasters, defense officials, forestry schools, and others associated with the protection of forest lands from fire will find it indispensable.

Fire Weather, Agriculture Handbook #360, printed in color, containing 229 pages and numerous illustrations, can be purchased for $3.75 from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402

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The Silent Tracker

D. B. Bradshaw[1]

A trained dog has proven valuable for fire investigation work in Nova Scotia. The dog is also an effective deterrent to incendiaries, who fear they may be tracked down even after they leave the fire area.

For the fourth consecutive season in Nova Scotia, a German Shepherd dog, Major, trained for tracking persons has been used to help curb forest fires started by incendiaries. Such fires have plagued fire control personnel throughout the Province's 40-year comprehensive fire prevention program.

Aircraft Partially Successful

During the 20-year period following World War II, the use of aircraft, both fixed wing and helicopter, proved partially successful as a preventive measure. However, in some counties of the province, the determined incendiary continued to have his way, perhaps more wary, but still undaunted. Clearly, a more impressive method of linking him with his handiwork was required.

The successful experience of the Royal Canadian Mounted Police in using a tracking dog to apprehend criminals, to locate lost hunters, children, and so on, was noted by provincial fire control personnel. The use of such a dog to deter the incendiary seemed reasonable.

Choosing a Dog

In early January of 1966, a Western Canadian firm, specializing in raising and training dogs for activities associated with police and security types of work, was contacted. The firm was asked by the Supervisor of Forest Protection to express its views on the feasibility of using a dog to track a "fire-bug" in a woodland area. The company considered this to be feasible, and suggested the German Shepherd and Doberman Pinscher as good breeds for the purpose. They offered to train a dog owned by the Department of Lands and Forests or to sell the Department a suitably trained dog.

Further correspondence established the particulars needed to train a dog to track in wooded areas under possibly smoky conditions. This included the preferable sex and age of the animal to be trained and a mutually acceptable leasing fee for a 2 or 3 month trial period.

In mid-April of 1966, the company was requested to ship a trained male German Shepherd to Halifax under lease for an initial period, with the possibility of purchase later on. On May 2nd, "Rommel" arrived at the Halifax International Airport.

Rommel

Within 2 weeks of his arrival in the province, Rommel was put to work in Halifax County. During the previous two months some 50 fires had occurred near a community in this county. When the dog arrived, two fires were in progress. Suppression action had started on one.

The dog was taken to the second fire where his initial attempt at tracking was unsuccessful due to confusion over an animal track. However, on being taken back to the fire, he followed a scent to a house in which a

See TRACKER, p. 15

Figure 1.—Commanded to "sit", Major awaits instruction from dogmaster. The four-year-old German Shepherd is used in forest protection and game law enforcement work in Nova Scotia. (N.S. Dept. of Lands & Forests)

[1] Forester i/c, Forest Protection, Nova Scotia Dept. of Lands and Forests.